MONTHLY WEATHER REVIEW.

Editor: Prof. CLEVELAND ABBE. Assistant Editor: CLEVELAND ABBE, jr.

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The MONTHLY WEATHER REVIEW summarizes the current manuscript data received from about 3,500 land stations in the United States and about 1,250 ocean vessels; it also gives the general results of the study of daily weather maps based on telegrams or cablegrams from about 200 North American and 40 European, Asiatic, and oceanic stations.

The hearty interest shown by all observers and correspondents is gratefully recognized.

Acknowledgment is also made of the specific cooperation of the following chiefs of independent, local, or governmental services: R. F. Stupart, Esq., Director of the Meteorological Service of the Dominion of Canada; Señor Manuel E. Pastrana, Director of the Central Meteorological and Magnetic Observatory of Mexico; Camilo A. Gonzales, Director-General of Mexican Telegraphs; Capt. I. S. Kimball, General Superintendent of the United States Life-Saving Service; Commandant Francisco S. Chaves, Director of the Meteorological Service of the Azores, Ponta Delgada, St. Michaels, Azores; W. N. Shaw, Esq., Director Meteorological Office, London; Maxwell Hall, Esq., Government Meteorologist, Kingston, Jamaica; Rev. L. Gangoiti, Director of the Meteorological Observatory of Belen College, Havana, Cuba; Luis G. y Carbonell, Director, Meteorological Service of Cuba, Havana, Cuba; Rev. José Algué, S. J., Director of the Weather Bureau, Manila Central Observatory, Philippines; Maj. Gen. M. A. Rykachef, Director of the Physical Central Observatory, St. Petersburg, Russia; Carl Ryder, Director, Danish Meteorological Institute, Copenhagen, Denmark.

As far as practicable the time of the seventy-fifth meridian is used in the text of the MONTHLY WEATHER REVIEW.

Barometric pressures, both at land stations and on ocean vessels, whether station pressures or sea-level pressures, are reduced, or assumed to be reduced, to standard gravity, as well as corrected for all instrumental peculiarities, so that they express pressure in the standard international system of measures, namely, by the height of an equivalent column of mercury at 32° Fahrenheit, under the standard force, i. e., apparent gravity at sea level and latitude 45°.

FORECASTS AND WARNINGS.

By Prof. E. B. GARRIOTT, in charge of Forecast Division.

As a rule temperatures were above the December average, except in the Pacific States, and there was no cold weather of consequence, except a little in the Northwest at the end of the month.

Precipitation was slightly in excess over portions of the Middle Atlantic States, but generally deficient elsewhere. There was a single heavy snow in the Middle Atlantic States, and over the middle and southern Rocky Mountain districts the snowfall was more abundant than usual at this season of the year.

A disturbance that moved down the eastern slope of the Rocky Mountains on the 4th and 5th, turned northeastward after reaching the Texas Panhandle, moving as a long trough with two distinct centers that finally joined into a single severe storm over New England on the evening of the 7th. This storm was attended by general rains and snows over the eastern half of the country and severe gales in the Lake region and the Middle and North Atlantic States. No cold followed, except in the South, where freezing temperatures were quite general on the morning of the 9th, except along the coast. Another storm appeared in British Columbia on the 9th, and reached New England on the 12th with greatly increased development. This storm was attended by general rains and snows over the northern districts, but was without high winds, and it was not followed by cold. There were several other quite general rain and snow periods, but none of marked character until the last few days of the month. A depression that appeared over extreme northwest British Columbia on the morning of the 28th moved across the northern portion of the country and reached the Canadian Maritime Provinces on the evening of the 31st. This storm was accompanied by moderate snows and rains and was followed in the Northwest by the only decided cold weather of the month. A moderate disturbance over Georgia on the morning of the 22d, in connection with a marked high area over Ontario, caused in the Middle Atlantic States the heavy snow incident to this type of pressure distribution.

Low pressure, with stormy weather, prevailed quite generally over western Europe from the 8th to the 22d, inclusive, the unsettled weather continuing over Great Britain until the end of the month. Toward the end of the month there was a heavy fall of snow thruout the British Islands and over portions of France.—*H. C. Frankenfield, Professor of Meteorology.*

BOSTON FORECAST DISTRICT.*

[New England.]

The month, as a whole, was exceptionally pleasant for the season. The precipitation was generally near the average in Vermont and eastern Maine, and below in nearly all other parts of the district. The temperatures were generally normal or slightly below in the northern, and above in the southern States. The snowfall was considerably below the average. At the end of the month the water in lakes and rivers was very low, and in Lake Champlain the lowest of record. General heavy rains are much needed in all sections of the district.

Heavy gales swept the entire coast on the 6-7th, with wind velocities approaching hurricane force in all sections. Fortunately there was no loss and little damage to shipping, so far as known at this office.

There were no storms without warnings.—*J. W. Smith, District Forecaster.*

NEW ORLEANS FORECAST DISTRICT.

[Louisiana, Texas, Oklahoma, and Arkansas.]

The weather during the month was abnormally warm and dry. No severe storm occurred along the Gulf coast and no warnings were issued. Cold-wave warnings were issued on a few dates for limited areas. The conditions on which the warnings were based diminished in intensity and as a result some of the warnings were not verified. No cold waves occurred without warnings. Frosts in the sugar and trucking region were covered by timely warnings.—*I. M. Cline, District Forecaster.*

LOUISVILLE FORECAST DISTRICT.*

[Kentucky and Tennessee.]

The first week and the last day of the month were quite cold, but the temperature was above normal during practically all the remainder of the month. The period 13–18th was exceptionally warm, during which time maximum temperatures registering between 60° and 70° were general. In eastern Tennessee the precipitation was somewhat above normal, but over the balance of Tennessee and Kentucky there was not much more than half the normal amount, altho well distributed in frequent showers. There was a good number of fair days and also of days with light rain.

Exceptionally few general disturbances past over the district. Of these only one or two were of any importance and even they were unattended by any severe stress of weather.

Cold-wave warnings were issued on the 6th and the 30th for the cold weather following those dates.—*F. J. Walz, District Forecaster.*

CHICAGO FORECAST DISTRICT.

[Indiana, Illinois, Michigan, Wisconsin, Minnesota, Iowa, Missouri, North Dakota, South Dakota, Nebraska, Kansas, and Montana.]

The month opened and closed with cold waves that covered the greater portion of the district. Ample warnings were given in each instance. During the 3d and 4th a barometric depression was attended by rain or snow from the lower Missouri Valley over the Ohio Valley and Lake region and was followed by a sharp fall in temperature.

A depression from the southwest crost the district during the 5th and 6th, attended by high winds in north and rain or snow in south portions, and followed by a cold wave that carried the line of zero temperature over southern Iowa on the morning of the 7th. Warnings for the territory covered by the cold wave were issued on the 6th and the usual warnings for high winds were sent to upper Lake stations.

From the 8th to 30th a succession of low areas over the northern portion of the district produced prevailing fair and warm weather, with frequent but not marked changes in temperature. During the afternoon and night of the 30th the temperature fell rapidly and continued low during the 31st. On Sunday, the 27th, announcement was made that a change to colder was indicated and that a winter type of weather would be experienced during the latter half of the week.

Navigation on the Great Lakes closed for the season after the 12th, and advisory warnings for high winds were issued only to open ports on Lake Michigan after that date.—*E. B. Garriott, Professor of Meteorology.*

DENVER FORECAST DISTRICT.*

[Wyoming, Colorado, Utah, New Mexico, and Arizona.]

Except in the southern portions of New Mexico and Arizona the month was colder than normal, especially in western Colorado and southern Utah. At Modena and Flagstaff lower temperatures were recorded than in any preceding December, but in the greater part of the district the low mean temperature was due to continued cool weather rather than to any very severe extremes.

The precipitation was remarkably heavy in Arizona and southwestern Colorado, exceeding all previous records for December at several stations. In northern Utah and northwestern Wyoming, as well as in New Mexico, there was a considerable deficiency. The more important storms of the month were of the southwestern type and were characteristically sluggish and erratic in movement.—*P. McDonough, Local Forecaster.*

SAN FRANCISCO FORECAST DISTRICT.†

[California and Nevada.]

As a whole the month was a cold, foggy period, with a marked deficiency in precipitation. Less than 50 per cent of the normal rainfall occurred. There were no prolonged rain periods and, with the exception of five days at the beginning of the month, rain was not recorded as lasting over forty-eight hours. In some respects the month resembled December, 1901. As a rule the low areas moved quickly across the northern portion of the Pacific slope.

There was an unusual amount of tule fog in the Great Valley, with temperatures ranging from 32° to 38°. The high humidity, low temperature, and absence of sunshine resulted in generally disagreeable weather. In the southern portion of the State frosts were heavy and frequent. Numerous warnings were sent to orange growers, both north and south, and at many places temperatures of 26° and 28° occurred. Thruout the long frost period no mistakes were made in forecasting.

The month began with a depression on the southern coast, which moved slowly southeastward. Unsettled weather continued until the 5th. A storm on the northern coast on the 8th moved southward and was followed by quickly clearing weather. Subsequent disturbances on the northern coast moved rapidly eastward.

There were no noteworthy failures in forecasting, except on December 16 a forecast of decidedly colder weather for Nevada was not made.—*Alexander G. McAdie, Professor of Meteorology.*

PORTLAND, OREG., FORECAST DISTRICT.†

[Oregon, Washington, and Idaho.]

December in this district was cold, with less than the usual amount of precipitation. The most severe disturbance of the month made its appearance over western Washington on Christmas morning, and shortly afterwards caused a maximum wind velocity of 90 miles from the southwest at Tatoosh Island, and 72 miles from the south at North Head, Wash. Another severe storm swept the district on the 12th, causing a wind velocity of 84 miles from the southwest at Tatoosh Island, Wash., and 74 miles from the south at North Head, Wash. Besides these two storms there were three others of moderate intensity, and warnings were issued for all of them in time to be of benefit.

A moderate cold spell prevailed from the 14th to the 22d, at which time the lowest temperatures of the month occurred. The principal periods with precipitation were from the 7th to the 15th, and from the 20th to the 28th.—*E. A. Beals, District Forecaster.*

RIVERS AND FLOODS.

The MONTHLY WEATHER REVIEW for November, 1908, stated that at the close of the month a flood was in progress in the Neosho and Arkansas rivers, and also in the rivers of Oklahoma. These floods were caused by heavy rains that began about November 22, and continued with an interval of two days until November 30. The floods did not extend north of Iola, Kans., on the Neosho River. They began at that place on the evening of the 29th, lasting but a day, with a crest stage of 9.5 feet, 0.5 foot below flood stage, and it was about the middle of December before the flood waters past into the Mississippi. The following reports on this flood have been received:

ARKANSAS RIVER AND TRIBUTARIES TO FORT SMITH, ARK.

By L. J. GUTHRIE, in charge of the local office of the Weather Bureau, Fort Smith, Ark.

Beginning November 22, and continuing four days, frequent, heavy rains occurred thruout Oklahoma and southern Kansas. These rains, tho local, were sufficient to thoroly saturate the soil and to cause a slight rise in all the streams of the district. Little or no rain fell on the 26th and 27th, but during the seventy-two hours ending 8 a. m. of the 30th, from 1.5 to 5 inches fell over the entire district. Owing to the saturated condition of the soil the effect of these general and heavy rains was immediate, especially upon the Neosho River. Rises of from

* Morning forecasts made at district center, night forecasts made at Washington, D. C.

† Morning and night forecasts made at district center.

4 to 10 feet in the Neosho from Le Roy, Kans., to Fort Gibson, Okla., and in the Arkansas from Tulsa, Okla, to Webbers Falls, Okla., occurred in the twenty-four hours ending 8 a. m. of the 29th. By the following morning the Neosho had risen 2 to 8 feet at all points, passing above the flood stages at Oswego, Kans., and Fort Gibson; and the Arkansas had risen 1.6 feet at Tulsa, 9 feet at Webbers Falls, and 10.5 feet at Fort Smith, Ark. The flood crest reached Oswego and Fort Gibson on December 1, Tulsa on November 30, Webbers Falls on December 1, and Fort Smith on December 2. The flood receded very slowly in the lower Neosho, and in the Arkansas below Fort Gibson, both continuing above flood stage from November 30 to December 6, inclusive.

A general flood warning for the Arkansas and Canadian and for the Neosho from Iola to Fort Gibson was issued at 10 a. m. of the 29th. The dissemination along the Neosho was practically complete, and the warning of inestimable value. The special river observers at Fort Gibson and Oswego, and the postmaster at Echo, were especially diligent in this work. Much property and doubtless a number of lives were saved thru their efforts to spread the warning. Interests on the Arkansas, also, were well protected, especially from Webbers Falls to Fort Smith and Van Buren, Ark. Tho the flood stage was not reached at Tulsa considerable damage ensued in that locality, and there, too, the warning was of great value.

The warning for the Canadian was not justified. It was based solely on reports from Calvin, no report of the rainfall at Oklahoma City being available when the warning was issued.

The highest stages reached were as follows: Emporia, Kans., 6.8 feet, on November 30; Neosho Rapids, Kans., 7.0 feet, on November 30; Le Roy, Kans., 20.6 feet, on November 30; Iola, Kans., 9.5 feet, on November 30; Oswego, Kans., 21.7 feet, on December 1; Fort Gibson, Okla., 31.0 feet, on December 1; Calvin, Okla., 8.4 feet, on November 29; Tulsa, Okla., 15.4 feet, on November 30; Webbers Falls, Okla., 26.5 feet, on December 1; Fort Smith, Ark., 29.0 feet, on December 2.

As in the October flood, a large percentage of the damage was caused by the smaller tributaries, among which may be mentioned the North Canadian, Cottonwood, and Little rivers, and Black Bear Creek. The flood, tho much higher stages were reached on the larger streams, was not as destructive as that of October, except as regards erosion. Fewer of the smaller streams were affected, and the matured crops that were reached by the recent flood had already been damaged or ruined. Then, too, much of the October damage to other property had not been repaired. Erosion was greater than during any of the previous floods of the year.

The money value of the property destroyed and damaged, including railroads and excluding crops, was $375,000.

The money value of crops destroyed and of damage to them was $95,000.

The damage to farm lands by erosion was $870,000.

Money value of losses occasioned by enforced suspension of business thru the flood, including wages of employees, was $85,000.

The value of property saved by the flood-warnings of the Weather Bureau was $300,000.

ARKANSAS RIVER FROM BELOW FORT SMITH, ARK., TO MOUTH.

By H. F. ALCIATORE, in charge of the local office of the Weather Bureau, Little Rock, Ark.

At Dardanelle, Ark., the river began to rise after the morning observation of November 28, and by 8 a. m. of December 1 had risen 13.2 feet to a stage of 23.0 feet, or 2 feet above flood stage. The wave crested December 3 with a stage of 25.3 feet. The river was above flood stage from December 1 to 7, inclusive.

At Little Rock the rise began November 30, and by 11 a. m., December 2, the water had risen 13.1 feet to flood stage, 23.0 feet. The wave crested at 5 p. m., December 4, with a stage of 24.8 feet. The water was above flood stage from December 2 to 7, inclusive.

At Pine Bluff, owing to the loss of the gage in the flood of October, 1908, no official stages are available for November and December, but the river observer reports that the December flood crested during the evening of December 5, with a stage estimated at 26.5 feet, and that the river had fallen about 0.3 foot by Sunday morning December 6, flood stage was at 25 feet.

Flood warnings were first issued on November 29, and daily thereafter until December 4, inclusive.

So far, as is known, no loss of life resulted from the December flood. At Van Buren, Ark., a short distance below Fort Smith, caving banks damaged the mains of the gas company; about 500 families were without gas for several days, and schools and city offices were closed for want of fuel.

The greatest damage was done at Pine Bluff, and was caused by the caving of the river bank, not by overflows, the under strata having been undermined by the swift current. The area affected was about twelve city blocks in length and averaged about one-half block in width. It is reported that about ninety-five buildings, six of which were brick, were destroyed or damaged. The $50,000 annex to the county court house was abandoned, as the rear wall of the building hangs over the river bank. The total damage to land and buildings is estimated at $100,000.

Ample and timely warnings of the approach of the flood wave were issued by the Weather Bureau, but, in the case of Pine Bluff, the river was so low at the time the warnings were issued that the U. S. Engineer fleet, near Rob Roy, Ark., which could have rendered valuable assistance in protecting the bank from erosion, could not pass the bar.

The flood was caused by heavy rains in the upper drainage basin, and was characterized by a sudden rise, swift current, and quick subsidence.

It will be seen from these reports that the floods were forecast with excellent judgment and accuracy, and the warnings were instrumental in saving lives and a great amount of property. No losses occured that could have been avoided.

The loss and damage amounted to something over $1,500,000. This is exclusive of the losses in central Oklahoma which would probably have brought the total up to at least $2,000,000. This flood was the fourth severe one of the year in Oklahoma, the previous ones having occurred in May, June, and October. Bottom lands all over the State were under water three or four times; crops were replanted two or three times, but the major portion was a failure.

There were moderate floods in the lower Roanoke and the rivers of the Santee System on the 23d and 24th, caused by rains about that time. Warnings were issued in ample time, and no losses have been reported. Many cattle were saved along the rivers of the Santee System.

Warnings were issued on the 22d and 23d for moderate tides in the Oconee and Ocmulgee rivers, of Georgia, and again on the 31st for the Ocmulgee River.

No other floods occurred except in Arizona. These were caused by heavy rains and snows about the middle of the month; an effort will be made to secure some detailed information regarding them.

The Ohio and upper Mississippi rivers were quite low, altho in the former conditions were somewhat improved. Navigation on the Mississippi, between Cairo and St. Louis, was practically suspended on the 22d.

ICE.

The Missouri River was closed by ice as far down as Bismarck, N. Dak., on the 1st; on the 4th as far as Sioux City, Iowa, and at Omaha, Nebr., on the 2d, opening again at the lat-

ter place on the 25th. Floating ice was observed as far south as Boonville, Mo., on the 7th. The James River at Huron, S. Dak., closed on the 3d, while the Red River of the North, at Moorhead, Minn., was closed during the entire month.

The Mississippi River closed at Fort Ripley, Minn., on the 6th; at St. Paul, Minn., on the 2d; at Red Wing, Minn., on the 1st; at La Crosse, Wis., on the 7th, and at Prairie du Chien, Wis., on the 2d. At Dubuque, Iowa, the ice gorged above the bridge on the 14th, but remained open below. At Leclaire, Iowa, the river closed on the 7th.

The rivers of Maine were closed after the 4th or 5th, while the Connecticut closed at Wells River, Vt., on the 3d, and at Whiteriver Junction, Vt., on the 9th.

The highest and lowest water, mean stage, and monthly range at 207 river stations are given in Table IV. Hydrographs for typical points on seven principal rivers are shown on Chart I. The stations selected for charting are Keokuk, St. Louis, Memphis, Vicksburg, and New Orleans, on the Mississippi; Cincinnati and Cairo, on the Ohio; Nashville, on the Cumberland; Johnsonville, on the Tennessee; Kansas City, on the Missouri; Little Rock, on the Arkansas; and Shreveport, on the Red.—*H. C. Frankenfield, Professor of Meteorology.*

SPECIAL ARTICLES, NOTES, AND EXTRACTS.

STUDIES ON THE VORTICES OF THE ATMOSPHERE OF THE EARTH.

By Prof. FRANK H. BIGELOW. Dated Washington, D. C., March 16, 1908.

V.—THE IMPERFECT TRUNCATED DUMB-BELL-SHAPED VORTEX AND THE COMPOSITION OF VORTICES ILLUSTRATED BY THE OCEAN-CYCLONE OF OCTOBER 11, 1905.

THE METEOROLOGICAL DATA.

A close examination of the isobars in the DeWitte typhoon[1] shows that there is a tendency to depart from the spacing which is required to produce the geometrical proportions called for by the formulas of the dumb-bell-shaped vortex. This feature is perceived first on the outer and on the inner isobars rather than in the middle ones of the group, and the general result is to change from a geometrical ratio for the radii to such a spacing as gives an equal distance between the successive radii of the series. This is equivalent to saying that the hyperbolic law, $v\varpi$=constant, which has been employed in the dumb-bell-shaped vortex, tends to become the parabolic law,

$\frac{v}{\varpi}$ = constant. (Compare the Cloud Report, pages 509, 620.) In the hyperbolic type of motion the gyration of the inner tubes is much greater than that of the outer tubes; in the parabolic type of motion the inner tangential velocities are not so great relatively as in the hyperbolic type. It is the purpose of this, and the following paper on the land-cyclone, to study the facts regarding this transition, and the thermodynamic causes which produce them. In the ocean-cyclone with strong development we find evidences of both of these types of motion in combination, and in the land-cyclone the parabolic type seems to be in the lead thruout the area of the local circulation. The subject is much complicated by the fact that the cyclone is generated by independent streams of warm and cold air which underrun the powerful eastward drift. This feature is influential in modifying the types of motion from pure forms to others that are quite incapable of being reduced to mathematical analysis of any simple kind.

The synoptic weather chart of the ocean-cyclone of October 11, 1905,[2] constructed by Mr. James Page (see fig. 17), contains much of the data required for study. Table 65 contains the geographical positions of 110 ships which rendered reports for October 11, 1905, at Greenwich mean noon, the wind direction and velocity, the barometric pressure and the temperature, all reduced to metric measures from extracts of the original records prepared by myself for this paper.

In order to eliminate the local conditions and secure the data for a symmetrical vortex about a central axis, we proceeded as follows: The linear diameters of the isobars were scaled on fig. 17, first in the northwest-southeast direction and then in the southwest-northeast direction, and the mean radii computed. Table 66 gives the computations from step to step.

[1] See Monthly Weather Review, October, 1908, **36**, p. 328, and Chart IX.
[2] See Monthly Weather Review, January, 1906, **34**, p. 5, fig. 3.

The columns contain in succession: (1) the barometric pressure in inches; (2), (3), the diameters of the isobars in two directions about 90° apart; (4) the sum of (2) and (3); (5) the

TABLE 65.—*Temperatures observed in the ocean-cyclone of October 11, 1905, at Greenwich mean noon.*

No.	Latitude N.	Longitude W.	Wind. Direction.	Wind. Meters per second.	B	T
					Mm.	° *C.*
1..			e.	8	762	10.0
2..						
3..	45.5	55.3	nne.	22	747	5.6
4..	50.6	27.3	sse.	13	766	14.6
5..	19.9	56.9	w.	6	758	28.0
6..	47.1	46.8	ne.	18	744	9.4
7..	41.6	42.6	se. & e. to sw.	40	719	20.6
8.	35.6	51.5	n.	22	744	20.0
9..	41.9	64.8	nne.	10	767	9.5
10..	39.6	49.6	nnw.	18	733	13.9
11..	42.8	61.0	ne.	13	768	10.0
12..	41.5	65.5	nne.	6	758	14.4
13..	49.8	26.1	sse.	10	766	15.5
14..	50.0	26.8	s.	10	767	13.9
15..	39.0	55.7	n.	18	756	12.8
16..	44.9	49.6	ne.	25	761	9.5
17..	50.7	25.6	se.	10	767	15.0
18..	50.8	43.4	ne.	15	748	13.3
19..	47.0	46.1	n.	22	746	10.0
20..	41.0	42.6	wsw.	34	720	17.8
21..	40.8	28.9	se.	13	761	21.1
22..	51.6	31.5	sse.	13	755	18.9
23..	48.4	49.1	nne.	18	747	7.3
25..	28.5	68.2	e. & n.	6	770	24.4
26..	45.1	48.9	ene.	29	743	8.4
27..	42.7	58.0	n.	13	761	10.0
28..	31.9	58.8	n.	4	758	24.0
29..	42.7	61.7	ne.	13	764	10.0
30..	45.8	49.9	nne.	25	744	9.0
31..	49.1	37.4	s.	5	752	18.4
32..	28.0	79.5	ene.	13	762	29.7
33..						
34..	20.2	61.7	nw.	6	764	24.6
35..	43.9	54.8	nne.	22	757	7.8
36..						
37.	42.9	58.6	ne.	15	755	7.0
38..	50.4	30.3	sse.	10	764	15.6
39..	42.3	44.0	n.	40	719	18.0
40.						
41..	21.7	67.0	nne.	8	763	27.7
42..	26.0	66.9	ene.	8	760	26.0
43..	49.5	27.4	sse.	10	765	14.5
44..	36.6	59.0	n.	23	763	19.5
45..	Horta, Azores.		se.	9	763	21.5
46..	50.4	29.5	sse.	10	765	14.4
47..	40.0	19.0	se.	10	762	13.9
48..	41.7	45.4	nnw.	40	716	16.7
49..	47.5	26.7	se.	4	764	16.2
50..	45.5	34.3	sse.	22	751	21.1
51..	41.6	66.3	nne.	8	766	13.0
52..	35.8	40.3	s. 60 w.	22	749	24.4
53..	49.1	34.1	sse.	18	759	16.2
54..	40.1	68.1	ne.	8	767	12.5
55..	49.8	12.0	ene.	10	773	15.0
56..	45.3	43.2	ene.	29	732	16.0
57..	49.5	32.0	se. by s.	18	758	16.2
58..	49.5	42.2	ne.	6	750	12.8
59..	Halifax		nw.	3	765	6.7
60..	40.3	30.0	s.	18	736	20.6
58a	36.1	42.1	wsw.	22	732	25.5
61.	40.3	47.3	wnw.	22	740	11.1
62.	30.0	67.4	ene.	4	760	24.4
63.	43.9	56.2	n.	22	762	8.9
64.	42.4	52.5	nnw.	29	755	11.1
65.	49.8	30.0	s.	15	760	14.4
66.	42.3	59.0	nne.	22	757	10.0
67.	40.5	33.5	s.	18	761	22.2
68.	45.2	47.0	ne.	25	727	8.9
69.	43.7	41.9	sse.	2	719	14.0
70.	22.4	34.5	sw.	13	764	25.0
71.	49.8	36.4	s. & e.	18	778	15.0
72.	44.6	49.8	n.	37	743	8.9
73.	50.2	28.3	s.	10	766	15.8
74.	36.2	66.8	wnw.	10	758	20.0
75.	40.6	73.1	ese.	13	761	17.5
76.	48.0	38.1	se.	25	747	17.3
77.						
78.	40.2	23.9	ene.	4	761	20.6
79.	49.2	44.5	ne.	15	740	10.0
80.	25.7	68.2	e. & s.	6	761	27.2
81.	42.6	60.0	ne.	15	762	10.0
82.	17.3	72.4	e.	6	758	— 1.0
83.	25.1	38.9	sse.	18	767	— 2.2
84.	43.3	53.7	n.	25	755	11.1
85.	54.0	22.5	se.	10	770	14.2
86	48.4	40.9	ne.	16	741	15.0
87.	42.5	48.5	n.	29	738	8.3
88.	Santa Cruz, Az.		se.	2	760	20.7
89.						
90.	48.2	51.3	n.	18	751	6.7
91.						
92.	44.3	53.9	nne.	18	753	—10.6
93.	51.2	19.0	sse.	10	766	15.6
94.	41.8	60.4	ne.	15	761	9.4
95.	16.0	47.3	se. & s.	10	760	26.6
96.	27.1	73.7	Var.	8	762	26.0
97.	30.8	52.4	nnw.	15	752	23.3
98.	40.2	48.0	n.	29	738	12.8
99.	51.6	44.3	nne.	13	745	10.6
100.						
101.	38.5	22.0	ne.	10	763	18.9
102.	44.7	46.7	ne.	40	703	13.3
103.	35.3	45.8	w.	18	734	20.0
104.	24.2	68.4	ene.	8	763	— 3.3
105.	43.8	56.2	n.	18	756	6.7
106.	46.5	47.0	nne.	22	744	9.4
107.	49.5	31.0	s.	15	757	13.9
108.	49.9	41.5	n.	2	751	—11.1
109.	38.8	69.6	e.	8	763	18.9
110.	49.5	32.8	s.	13	755	16.2

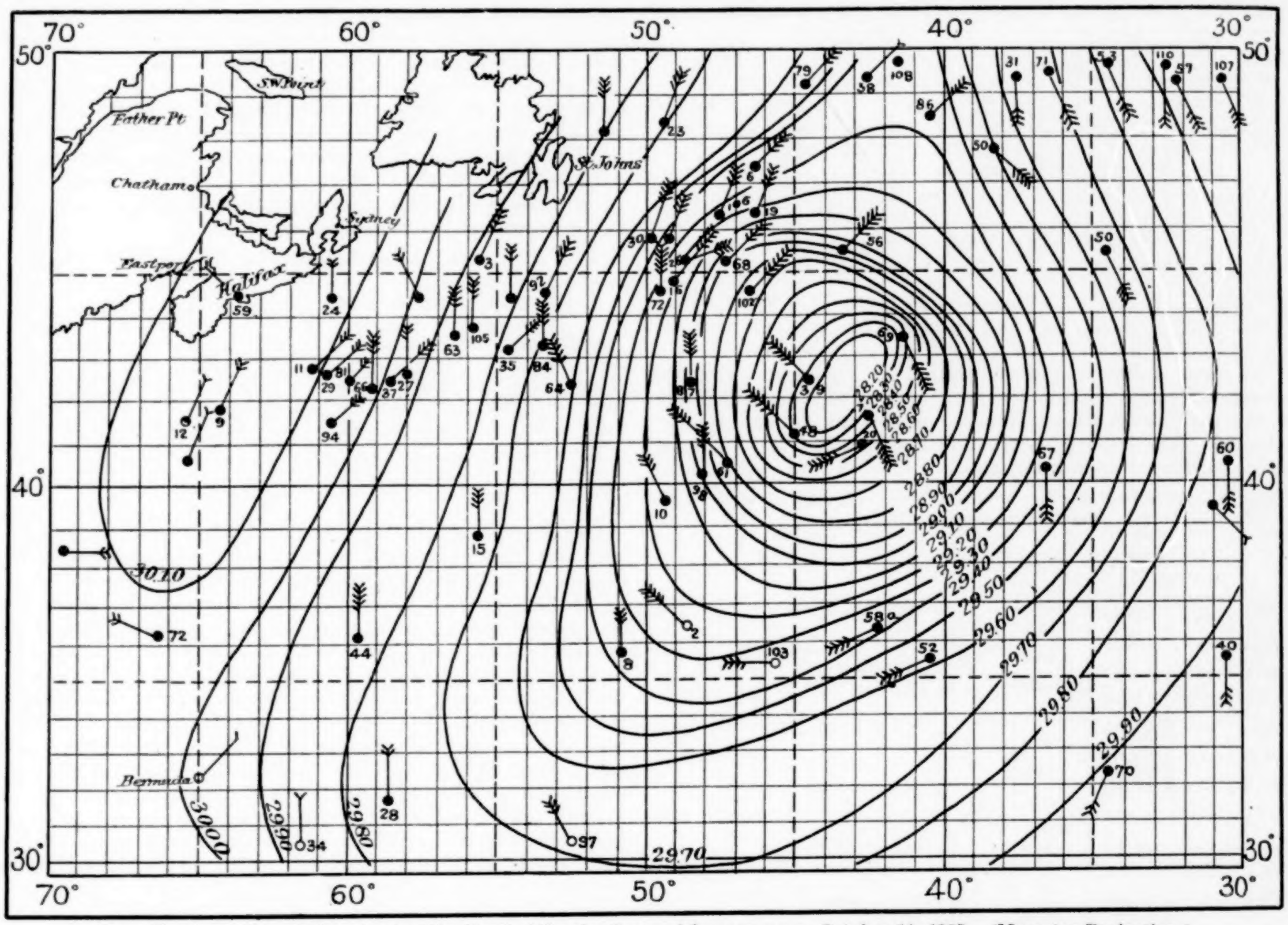

FIG. 17.—Synoptic weather chart of the North Atlantic, Greenwich mean noon, October 11, 1905. (Mercator Projection.)

mean radius ϖ; and (6) the difference $\Delta\varpi$. These values were plotted on a diagram and after drawing a mean curve, the smoothed results were placed in (7) and (8). The log ϖ and log ρ are given in (9) and (10). The metric equivalent of B in inches is given in (11); the values of B for the intervals beginning with 760 millimeters in (12) as interpolated from B in (11); and the corresponding smoothed ϖ in (13).

The last two columns of Table 66, giving B and ϖ, are transferred to Table 68, where the adjustment of the radii and the velocities are computed. From log ϖ_n is found $\log \rho = \log \varpi_n - \log \varpi_{n+1}$. The values of log ρ are nearly constant from $B = 755.0$ to $B = 730.0$, while they are somewhat larger above 755.0 and gradually increase below 730.0. This shows that the radii, as scaled from the chart, do not conform to a logarithmic law, except in the middle group of isobars. This may be due partly to imperfect data, because the drawing of the isobars, especially near the center, may be inaccurate, and partly to the fact that the vortex is really impure and departs from the true vortex law in consequence of the system of forces that has generated it, especially the asymmetric distribution of the temperature which begins to show at the surface in the ocean-cyclone, and to distinguish these vortices from the more perfect vortices observed in hurricanes. We find the mean,

$$\log \rho_m = 0.05354 \text{ for 2.5 mm. intervals.}$$

The velocities were next considered, and a collection of the observed tangential velocities v, on or near each isobar, was made, so that the mean tangential velocity on each isobar could be computed. See Table 67.

TABLE 66.—*Adjustment of the isobars and the radii to a symmetrical type about the z-axis.*

B	Diameters of isobars.				$\Delta\varpi$	Adjusted.		log ϖ	log ρ	B	Adjusted.	
	NW.	SW.	Sum	ϖ		$\Delta\varpi$	ϖ				B	ϖ
Ins.	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*			*Mm.*	*Mm.*	*Mm.*
29.90	126	175	301	75.3			75.3	1.87679		759.5	760.0	76.0
					9.8	10.8			0.06723			
29.80	106	156	262	65.5			64.5	1.80956		756.9	757.5	66.4
					9.9	8.5			0.06137			
29.70	93	130	223	55.6			56.9	1.74819		754.4	755.0	57.0
					8.1	6.9			0.05711			
29.60	82	108	190	47.5			49.1	1.69108		751.8	752.5	50.4
					4.5	5.8			0.05459			
29.50	76	96	172	43.0			43.3	1.63649		749.3	750.0	45.0
					4.5	5.2			0.05557			
29.40	69	85	154	38.5			38.1	1.58092		746.8	747.5	39.8
					4.0	4.5			0.05458			
29.30	63	75	138	34.5			33.6	1.52634		744.2	745.0	35.0
					4.0	3.8			0.05212			
29.20	58	64	122	30.5			29.8	1.47422		741.7	742.5	31.2
					4.0	3.4			0.05262			
29.10	54	52	106	26.5			26.4	1.42160		739.1	740.0	27.8
					2.5	3.0			0.05168			
29.00	50	46	96	24.0			23.4	1.36922		736.6	737.5	24.5
					1.7	2.7			0.05325			
28.90	46	43	89	22.3			20.7	1.31597		734.1	735.0	21.6
					3.0	2.4			0.05352			
28.80	39	38	77	19.3			18.3	1.26245		731.5	732.5	19.4
					2.8	2.3			0.05833			
28.70	33	33	66	16.5			16.0	1.20412		729.0	730.0	17.0
					2.2	2.1			0.06111			
28.60	26	31	57	14.3			13.9	1.14301		726.4	727.5	14.8
					1.8	2.0			0.07113			
28.50	21	29	50	12.5			11.8	1.07188		723.9	725.0	12.7
					2.5	2.0			0.08065			
28.40	16	24	40	10.0			9.8	0.99123		721.4	722.5	10.6
					2.0	2.0			0.09914			
28.30	11	21	32	8.0			7.8	0.89209		718.8	720.0	8.7
					2.2	2.0			0.12866			
28.20	7	16	23	5.8			5.8	0.76343		716.3	717.5	6.6

TABLE 67.—*The observed tangential velocities, v, in meters per second.*

Isobars.	760	755	750	745	740	735	730	725	720
Velocities observed at points along the isobars.	18	15	22	22	22	25	40	34	40
	10	18	25	34	22	22	25		37
	15	18	29	22	25	25			40
	15	22	22	25	22				40
	22	18	22	15	34				
	18	22	22	18	18				
	10	29		22					
	25	18		18					
	8	10		18					
	13	15							
	13	6							
	5								
	18								
Means	14.2	17.4	23.7	21.6	23.8	24.0	32.5	34.0	39.3
Smoothed	14.2	16.5	19.0	21.5	24.5	27.6	31.0	33.0	38.0

The mean values of v were plotted on a diagram, and the average curve drawn thru the points gave the smoothed values of v in the lowest line. This is transferred to column (6), Table 68. The log v is taken, and $\log \sigma = \log v_{n+1} - \log v_n$ computed for 5.0 mm. intervals.

TABLE 68.—*Determination of log ρ from the smoothed radii ϖ_n; and of log σ from the smoothed velocities v_n.*

B	ϖ	log ϖ	log ρ		v	log v	log σ	
Mm.	*Mm.*			Mean log ρ_m = 0.05304 for 2.5 mm. intervals. Adopted log ρ_m = 0.05300.	*M. p. s.*			Mean log σ = 0.05222 for 5.0 mm. intervals. Adopted log σ = 0.05300.
760.0	76.0	1.88031			14.2	1.15229		
			0.05864					
757.5	66.4	1.82217					.06519	
			0.06630					
755.0	57.0	1.75587			16.5	1.21748		
			0.05344					
752.5	50.4	1.70243					.06127	
			0.04922					
750.0	45.0	1.65321			19.0	1.27875		
			0.05333					
747.5	39.8	1.59988					.05369	
			0.05581					
745.0	35.0	1.54407			21.5	1.33244		
			0.04992					
742.5	31.2	1.49415					.05573	
			0.05011					
740.0	27.8	1.44404			24.5	1.38917		
			0.05487					
737.5	24.5	1.38917					.05174	
			0.05472					
735.0	21.6	1.33445			27.6	1.44091		
			0.05665					
732.5	19.4	1.28780					.05045	
			0.05735					
730.0	17.0	1.23045			31.0	1.49136		
			0.06019					
727.5	14.8	1.17026					.04646	
			0.06646					
725.0	12.7	1.10380			34.5	1.53782		
			0.07849					
722.5	10.6	1.02531					.04196	
			0.08579					
720.0	8.7	0.93952			38.0	1.57978		
			0.11998					
717.5	6.6	0.81954					.04347	
			0.15678					
715.0	4.6	0.66276			42.0	1.62325		

It is seen that while log σ decreases, the range is not very great, and the mean value of log σ for 5.0 mm. intervals is

$$\log \sigma_m = 0.05222.$$

The log σ is taken for isobars at twice as great intervals as was used for computing log ρ_m, so that we may adopt the following average values,

$$\log \rho_m = 2 \log \sigma_m = 0.10600$$

when the isobars are 760, 755, 750, ..., 715. Adopt the values of ϖ and v at the 760 mm. isobar as the standard, and compute new values, using the average value of log ρ_m thruout the system.

With the adopted constant logarithms of ρ and σ derived from Table 68, and the following formulas:

$$\log \varpi_{n+1} = \log \varpi_n - \log \rho = \log \varpi_n - 0.10600$$
$$\log v_{n+1} = \log v_n + \tfrac{1}{2} \log \rho = \log v_n + 0.05300$$
$$\log a\psi_{n+1} = \log a\psi_n - \tfrac{1}{2} \log \rho = \log a\psi_n - 0.05300$$

compute the values of log ϖ, log v, log $a\psi_n$ as given in columns 3, 7, and 8, of Table 69. The second column of the table gives the corresponding or final adjusted values of ϖ appropriate to the original chart, fig. 17, whose scale is such that 1 mm. = 20000 m. = 20 km. = 12.4 miles.

The fourth column gives the logarithm of the equivalent ϖ in meters on the surface of the globe, and the fifth column its value in kilometers.. The sixth column gives the adjusted value of v in meters per second corresponding to the *adjusted* values of log v in the seventh column. The computed values agree closely with those obtained from the chart and data of Table 65, except near the center.

TABLE 69.—*Adjusted values of log ϖ_n, log v_n, log $a\psi_n$.*

B	ϖ	log ϖ	log ϖ	ϖ	v	log v	log $a\psi_n$
Mm.	*Mm.*			*Km.*	*M. p. s.*		
760	73.3	1.86522	6.16625	1466.4	14.9	1.17275	7.33900
755	57.4	1.75922	6.06025	1148.8	16.8	1.22575	7.28600
750	45.0	1.65322	5.95425	900.0	19.0	1.27875	7.23300
745	35.3	1.54722	5.84825	705.1	21.5	1.33175	7.18000
740	27.7	1.44122	5.74225	552.4	24.3	1.38475	7.12700
735	21.6	1.33522	5.63625	432.8	27.4	1.43775	7.07400
730	17.0	1.22922	5.53025	339.0	31.0	1.49075	7.02100
725	13.3	1.12322	5.42425	265.6	35.0	1.54375	6.96800
720	10.4	1.01722	5.31825	208.1	39.5	1.59675	6.91500
715	8.2	0.91122	5.21225	163.0	44.6	1.64975	6.86200

Our purpose is now to determine the average vortex system that is nearly equivalent to the observed ocean-cyclone, and compare it with the pure vortex from which it may be assumed to have departed. The differences between the perfect and the imperfect vortices will enable us to construct the *disturbing vortex* system that transforms the vortex of hurricane type into the observed cyclone. The thermodynamic forces which will produce such a disturbing vortex may be attributed to the asymmetric distribution of the air masses of different temperatures around the axis of gyration. It is noted in the last column of Table 69 that the $\log a\psi = \log \varpi v$ is not a constant as it should be in the perfect vortex, because the tangential velocities are not great enough along the inner isobars to conform to the vortex which is represented by the outer isobars. It will be necessary then to continue this computation with a *variable current function*.

COMPUTATIONS FOR A, ϖ, u, v, w, IN THE IMPERFECT AND IN THE PERFECT VORTICES ON THE PLANE OF REFERENCE $az = 50°$.

It was decided to begin the computations on the plane $az = 50°$, near the sea-level, to give an inflowing angle $i = -40°$. The angle probably lies between $-40°$ and $-30°$, and this will place the plane of greatest angular velocity in the strato-cumulus level, about 3,000 meters above the sea-level. At the same time the elevation of the upper plane is taken 8,000 meters above the sea-level, instead of 12,000 meters as in the DeWitte typhoon. This gives us,

$$a = \frac{180°}{8000 + 4000} = 0.015°,$$

as the angle-constant. It may be that this plane should be taken somewhat higher, but it is probable that the eastward drift into which this cyclone penetrates practically destroys the vortex head near that level. This is, of course, a point for a more careful research. Table 70 contains the computations of A_1, ϖ_1, u_1, v_1, w_1, in the simplest order for the imperfect vortex with a *variable* value of the current function $a\psi$. Table 71 contains a similar computation of A_0, ϖ_0, u_0, v_0, w_0, for the perfect vortex with a constant value of the current function. A comparison of the values of the velocities in Tables 70 and 71 shows how great a disturbance of the perfect vortex has been effected. It is the problem, in a correct theory of the cyclone, to account for these differences of the velocities. In Tables 72 and 73 the results are extended to the 10-degree values of az from 50° to 180°, and these enable us to proceed with the discussion of the temperature distribution that is properly responsible for these motions of the atmosphere.

TABLE 70.—*The imperfect dumb-bell-shaped vortex.*

Computations on the plane $az = 50°$.

	Current F.	$\psi = A\varpi^2 \sin az.$	Radius $\varpi = \left(\dfrac{a\psi}{A a \sin az} \right)^{\frac{1}{2}}$	$a = \dfrac{180°}{8000 + 4000}.$
Velocities.	Radial.	$u = - A a \varpi \cos az.$		
	Tangential.	$v = + A a \varpi \sin az.$	Constant $A = \dfrac{v}{a \varpi \sin az}$	$a = \dfrac{180°}{12000} = 0.015°.$
	Vertical.	$w = + 2A \sin az.$		$\log a = 8.17609.$
	Constants.	$\log \rho = 0.10600.$ $\log \sigma = 0.05300.$	$\log \sin 50° = 9.88425$ $\log \cos 50° = 9.80807$	$\log a \sin az = 8.06034.$ $\log a \cos az = 7.93416.$

Variable $a\psi$. The values of A_1, ϖ_1, u_1, v_1, w_1.

Term.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
$\log a\psi$	7.33900	7.28600	7.23300	7.18000	7.12700	7.07400	7.02100	6.96800	6.91500	6.86200
$\log \varpi$	6.16625	6.06025	5.95425	5.84825	5.74225	5.63625	5.53025	5.42425	5.31825	5.21225
ϖ (meters)	1466400.	1148800.	900020.	705100.	552400.	432760.	339040.	265610.	208090.	163020.
$\log v_1$	1.17275	1.22575	1.27875	1.33175	1.38475	1.43775	1.49075	1.54375	1.59675	1.64975
v_1	14.9	16.8	19.0	21.5	24.3	27.4	31.0	35.0	39.5	44.6
$a\varpi \sin az$	4.22659	4.12059	4.01459	3.90859	3.80259	3.69659	3.59059	3.48459	3.37859	3.27259
$\log A_1$	6.94616	7.10516	7.26416	7.42316	7.58216	7.74116	7.90016	8.05916	8.21816	8.37716
A_1	.00089	.00127	.00184	.00265	.00382	.00551	.00795	.01146	.01653	.02383
$\log u_1$	−1.09657	−1.14957	−1.20257	−1.25557	−1.30857	−1.36157	−1.41457	−1.46757	−1.52057	−1.57357
u_1	−12.5	−14.1	−16.0	−18.0	−20.4	−23.0	−26.0	−29.4	−33.2	−37.5
$\log w_1$	7.13144	7.29044	7.44944	7.60844	7.76744	7.92644	8.08544	8.24444	8.40344	8.56244
w_1	.00135	.00195	.00282	.00406	.00585	.00844	.01217	.01756	.02532	.03651

TABLE 71.—*The perfect dumb-bell-shaped vortex.*

Constant $a\psi$. The values of A_0, ϖ_0, u_0, v_0, w_0.

Term.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
$\log a\psi$	7.33900	7.33900	7.33900	7.33900	7.33900	7.33900	7.33900	7.33900	7.33900	7.33900
$\log \varpi$	6.16625	6.06025	5.95425	5.84825	5.74225	5.63625	5.53025	5.42425	5.31825	5.21225
ϖ (meters)	1466400.	1148800.	900020.	705100.	552400.	432760.	339040.	265610.	208090.	163020.
$\log v_0$	1.17275	1.27875	1.38475	1.49075	1.59675	1.70275	1.80875	1.91475	2.02075	2.12675
v_0	14.9	19.0	24.2	29.6	39.5	50.8	64.4	82.2	104.9	133.9
$a\varpi \sin az$	4.22659	4.12059	4.01459	3.90859	3.80259	3.69659	3.59059	3.48459	3.37859	3.27259
$\log A_0$	6.94616	7.15816	7.37016	7.58216	7.79416	8.00616	8.21816	8.43016	8.64216	8.85416
A_0	.00089	.00144	.00235	.00382	.00623	.01014	.01653	.02699	.04387	.07148
$\log u_0$	−1.09657	−1.20257	−1.30857	−1.41457	−1.52057	−1.62657	−1.73257	−1.83857	−1.94457	−2.05057
u_0	−12.5	−15.9	−20.4	−26.0	−33.2	−42.3	−54.0	−69.0	−88.0	−112.3
$\log w_0$	7.13144	7.34344	7.55544	7.76744	7.97944	8.19144	8.40344	8.61544	8.82744	9.03944
w_0	.00135	.00221	.00359	.00585	.00954	.01554	.02532	.04125	.06721	.10951

TABLE 72.—*The imperfect dumb-bell-shaped vortex, ψ_1. Results from the truncating plane $az=50°$.*

The radii ϖ in kilometers.

Altitude.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
° $az=180$	∞	∞	∞	∞	∞	∞	∞	∞
170	3079.9	2412.9	1890.3	1480.6	1160.2	909.0	712.1	557.9
160	2194.6	1719.3	1346.9	1055.2	826.7	647.7	507.4	397.5
150	1815.0	1422.0	1114.0	872.8	683.7	535.7	419.6	328.8
140	1600.8	1254.1	982.5	769.7	603.0	472.4	370.1	290.0
130	1466.4	1148.8	900.0	705.1	552.4	432.8	339.0	265.6
120	1379.2	1080.5	846.5	663.2	519.5	407.0	318.9	249.8
110	1324.0	1037.2	821.6	636.6	498.8	390.7	306.1	239.8
100	1293.3	1013.2	793.8	621.9	487.2	381.7	299.0	234.3
90	1283.4	1005.5	787.7	617.0	483.5	378.8	296.7	232.5
80	1293.3	1013.2	793.8	621.9	487.2	381.7	299.0	234.3
70	1324.0	1037.2	812.6	636.6	498.8	490.7	306.1	239.8
60	1379.2	1080.5	793.8	663.2	519.5	407.0	318.9	249.8
50	1466.4	1148.8	787.7	705.1	552.4	432.8	339.0	265.6

The radial velocity u_1 in meters per second.

Altitude.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
° $az=180$	∞	∞	∞	∞	∞	∞	∞	∞
170	40.2	45.4	51.3	58.0	65.5	74.0	83.6	94.4
160	27.3	30.9	34.9	39.4	44.5	50.3	56.8	64.2
150	20.8	23.5	26.6	30.0	33.9	38.3	43.0	48.9
140	16.2	18.4	20.7	23.4	26.5	29.9	33.8	38.1
130	12.5	14.1	16.0	18.0	20.4	23.0	26.0	29.4
120	9.1	10.3	11.7	13.2	14.9	16.8	19.0	21.5
110	6.0	6.8	7.7	8.7	9.8	11.0	12.5	14.1
100	3.0	3.4	3.8	4.3	4.8	5.5	6.2	7.0
90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
80	− 3.0	− 3.4	− 3.8	− 4.3	− 4.8	− 5.5	− 6.2	− 7.0
70	− 6.0	− 6.8	− 7.7	− 8.7	− 9.8	−11.0	−12.5	−14.1
60	− 9.1	−10.3	−11.7	−13.2	−14.9	−16.8	−19.0	−21.5
50	−12.5	−14.1	−16.0	−18.0	−20.4	−23.0	−26.0	−29.4

TABLE 72.—*The imperfect dumb-bell-shaped vortex,* ψ_1. *Results from the truncating plane* $az=50°$—Continued.

The tangential velocity v_1 in meters per second.

Altitude.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
°								
az=180	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
170	7.1	8.0	9.0	10.2	11.6	13.0	14.7	16.7
160	9.9	11.2	12.7	14.3	16.2	18.3	20.7	23.4
150	12.0	13.6	15.4	17.3	19.6	22.1	25.0	28.3
140	13.6	15.4	17.4	19.7	22.2	25.1	28.4	32.0
130	14.9	16.8	19.0	21.5	24.3	27.4	31.0	35.0
120	15.8	17.9	20.2	22.8	25.8	29.1	32.9	37.2
110	16.5	18.6	21.0	23.8	26.9	30.3	34.3	38.7
100	16.9	19.1	21.5	24.3	27.5	31.1	35.1	39.7
90	17.0	19.2	21.7	24.5	27.7	31.3	35.4	40.0
80	16.9	19.1	21.5	24.3	27.5	31.1	35.1	39.7
70	16.5	18.6	21.0	23.8	26.9	30.3	34.3	38.7
60	15.8	17.9	20.2	22.8	25.8	29.1	32.9	37.2
50	14.9	16.8	19.0	21.5	24.3	27.4	31.0	35.0

The vertical velocity w_1 in meters per second.

Altitude.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
az=180	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
170	.0003	.0004	.0006	.0009	.0013	.0019	.0028	.0040
160	.0006	.0009	.0013	.0018	.0026	.0038	.0054	.0078
150	.0009	.0013	.0018	.0026	.0038	.0055	.0079	.0115
140	.0012	.0016	.0024	.0034	.0049	.0071	.0102	.0147
130	.0014	.0020	.0028	.0041	.0059	.0084	.0122	.0176
120	.0015	.0022	.0032	.0046	.0066	.0095	.0138	.0198
110	.0016	.0024	.0035	.0050	.0072	.0104	.0149	.0215
100	.0017	.0025	.0036	.0052	.0075	.0109	.0157	.0226
90	.0018	.0025	.0037	.0053	.0076	.0110	.0159	.0229
80	.0017	.0025	.0036	.0052	.0075	.0109	.0157	.0226
70	.0016	.0024	.0035	.0050	.0072	.0104	.0149	.0215
60	.0015	.0022	.0032	.0046	.0066	.0095	.0138	.0198
50	.0014	.0020	.0028	.0041	.0059	.0084	.0122	.0176

TABLE 73.—*The perfect dumb-bell-shaped vortex,* ψ_0.

The radii ϖ remain the same (see table 72).

The radial velocity u_0 in meters per second.

Altitude.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
°								
az=180	∞	∞	∞	∞	∞	∞	∞	∞
170	40.2	51.3	65.5	83.6	106.7	136.2	173.8	221.9
160	27.3	34.9	44.5	56.8	72.5	92.6	118.2	150.9
150	20.8	26.6	33.9	43.3	55.3	70.6	90.1	115.0
140	16.2	20.7	26.5	33.8	43.1	55.1	70.3	89.7
130	12.5	15.9	20.4	26.0	33.2	42.3	54.0	69.0
120	9.1	11.7	14.9	19.0	24.3	31.0	39.5	50.4
110	6.0	7.7	9.7	12.5	15.9	20.3	26.0	33.1
100	3.0	3.8	4.8	6.2	7.9	10.1	12.9	16.4
90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
80	− 3.0	− 3.8	− 4.8	− 6.2	− 7.9	−10.1	−12.9	−16.4
70	− 6.0	− 7.7	− 9.7	−12.5	−15.9	−20.3	−26.0	−33.1
60	− 9.1	−11.7	−14.9	−19.0	−24.3	−31.0	−39.5	−50.4
50	−12.5	−15.9	−20.4	−26.0	−33.2	−42.3	−54.0	−69.0

The tangential velocity v_0 in meters per second.

Altitude.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
az=180	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
170	7.1	9.0	11.6	14.7	18.8	24.0	30.7	39.1
160	9.9	12.7	16.2	20.7	26.4	33.7	43.0	54.9
150	12.0	15.4	19.6	25.0	31.9	40.8	52.0	66.4
140	13.6	17.4	22.2	28.4	36.2	46.2	59.0	75.3
130	14.9	19.0	24.2	31.0	39.5	50.4	64.4	82.2
120	15.8	20.2	25.8	32.8	42.0	53.6	68.5	87.4
110	16.5	21.0	26.9	34.3	43.8	55.9	71.3	91.0
100	16.9	21.5	27.5	35.1	44.8	57.2	73.0	93.2
90	17.0	21.7	27.7	35.4	45.1	57.6	73.6	93.9
80	16.9	21.5	27.5	35.1	44.8	57.2	73.0	93.2
70	16.5	21.0	26.9	34.3	43.8	55.9	71.3	91.0
60	15.8	20.2	25.8	32.8	42.0	53.6	68.5	87.4
50	14.9	19.0	24.2	31.0	39.5	50.4	64.4	82.2

The vertical velocity w_0 in meters per second.

Altitude.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
az=180	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
170	.0003	.0005	.0008	.0013	.0022	.0035	.0057	.0094
160	.0006	.0010	.0016	.0026	.0043	.0069	.0113	.0184
150	.0009	.0014	.0024	.0038	.0062	.0101	.0165	.0269
140	.0012	.0018	.0030	.0049	.0080	.0130	.0212	.0346
130	.0014	.0022	.0036	.0058	.0095	.0155	.0253	.0412
120	.0015	.0025	.0041	.0066	.0108	.0176	.0286	.0466
110	.0016	.0027	.0044	.0072	.0117	.0191	.0311	.0506
100	.0017	.0028	.0046	.0075	.0123	.0202	.0326	.0530
90	.0018	.0029	.0047	.0076	.0124	.0203	.0331	.0538
80	.0017	.0028	.0046	.0075	.0123	.0202	.0326	.0530
70	.0016	.0027	.0044	.0072	.0117	.0191	.0311	.0506
60	.0015	.0025	.0041	.0066	.0108	.0176	.0286	.0466
50	.0014	.0022	.0036	.0058	.0095	.0155	.0253	.0412

TABLE 74.—*The component vortex,* $\psi_1-\psi_0=\psi_2$. *The reversing vortex.*

The radii ϖ remain the same (see table 72).

The radial velocity $u_2=u_1-u_0$.

Altitude.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
°								
az=180	—	—	—	—	—	—	—	—
170	0.0	−5.9	−14.2	−25.6	−41.2	−62.2	−90.2	−127.5
160	0.0	−4.0	− 9.6	−17.4	−28.0	−42.3	−61.4	− 86.7
150	0.0	−3.1	− 7.3	−13.3	−21.4	−32.3	−47.1	− 66.1
140	0.0	−2.3	− 5.8	−10.4	−16.6	−25.2	−36.5	− 51.6
130	0.0	−1.8	− 4.4	− 8.0	−12.8	−19.3	−28.0	− 39.6
120	0.0	−1.4	− 3.2	− 5.8	− 9.4	−14.2	−20.5	− 28.9
110	0.0	−0.9	− 2.0	− 3.8	− 6.1	− 9.3	−13.5	− 19.6
100	0.0	−0.4	− 1.0	− 1.9	− 3.1	− 4.6	− 6.7	− 9.4
90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
80	0.0	+0.4	+ 1.0	+ 1.9	+ 3.1	+ 4.6	+ 6.7	+ 9.4
70	0.0	+0.9	+ 2.0	+ 3.8	+ 6.1	+ 9.3	+13.5	+ 19.0
60	0.0	+1.4	+ 3.2	+ 5.8	+ 9.4	+14.2	+20.5	+ 28.9
50	0.0	+1.8	+ 4.4	+ 8.0	+12.8	+19.3	+28.0	+ 39.6

The tangential velocity $v_2=v_1-v_0$.

Altitude.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
az=180	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
170	0.0	−1.0	−2.6	− 4.5	− 7.2	−11.0	−16.0	−22.4
160	0.0	−1.5	−3.5	− 6.4	−10.2	−15.4	−22.3	−31.5
150	0.0	−1.8	−4.2	− 7.7	−12.3	−18.7	−27.0	−38.1
140	0.0	−2.0	−4.8	− 8.7	−14.0	−21.1	−30.6	−43.3
130	0.0	−2.2	−5.2	− 9.5	−15.2	−23.0	−33.4	−47.2
120	0.0	−2.3	−5.6	−10.0	−16.2	−24.5	−35.6	−50.2
110	0.0	−2.4	−5.9	−10.5	−16.9	−25.6	−37.0	−52.3
100	0.0	−2.4	−6.0	−10.8	−17.3	−26.1	−37.9	−53.5
90	0.0	−2.5	−6.0	−10.9	−17.4	−26.3	−38.2	−53.9
80	0.0	−2.4	−6.0	−10.8	−17.3	−26.1	−37.9	−53.5
70	0.0	−2.4	−5.9	−10.5	−16.9	−25.6	−37.0	−52.3
60	0.0	−2.3	−5.6	−10.0	−16.2	−24.5	−35.6	−50.2
50	0.0	−2.2	−5.2	− 9.5	−15.2	−23.0	−33.4	−47.2

The vertical velocity $w_2=w_1-w_0$.

Altitude.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
az=180	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
170	.0000	−.0001	−.0004	−.0009	−.0016	−.0029	−.0054	−.0095
160	.0000	−.0001	−.0008	−.0017	−.0031	−.0059	−.0106	−.0187
150	.0000	−.0001	−.0012	−.0024	−.0046	−.0086	−.0154	−.0274
140	.0000	−.0002	−.0015	−.0031	−.0039	−.0110	−.0199	−.0352
130	.0000	−.0002	−.0017	−.0036	−.0071	−.0131	−.0236	−.0419
120	.0000	−.0003	−.0020	−.0042	−.0081	−.0148	−.0268	−.0474
110	.0000	−.0003	−.0022	−.0045	−.0087	−.0162	−.0291	−.0513
100	.0000	−.0003	−.0023	−.0048	−.0093	−.0169	−.0301	−.0539
90	.0000	−.0004	−.0023	−.0048	−.0093	−.0172	−.0309	−.0546
80	.0000	−.0003	−.0023	−.0048	−.0093	−.0169	−.0301	−.0539
70	.0000	−.0003	−.0022	−.0045	−.0087	−.0162	−.0291	−.0513
60	.0000	−.0003	−.0020	−.0042	−.0081	−.0148	−.0268	−.0474
50	.0000	−.0002	−.0017	−.0036	−.0071	−.0131	−.0236	−.0419

The total velocity $q_2=q_1-q_0$.

Altitude.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
az=180	—	—	—	—	—	—	—	—
170	0.0	−6.0	−14.4	−26.6	−41.8	−63.2	−91.6	−129.4
160	0.0	−4.2	−10.3	−18.6	−29.8	−45.0	−65.3	− 92.2
150	0.0	−3.5	− 8.5	−15.3	−24.7	−37.2	−54.0	− 76.3
140	0.0	−3.1	− 7.5	−13.5	−21.7	−32.9	−47.7	− 67.3
130	0.0	−2.8	− 6.9	−12.4	−19.9	−30.1	−43.6	− 61.6
120	0.0	−2.7	− 6.5	−11.5	−18.7	−28.3	−41.0	− 58.0
110	0.0	−2.6	− 6.2	−11.2	−18.0	−27.2	−39.4	− 55.7
100	0.0	−2.5	− 6.0	−10.9	−17.6	−26.6	−38.5	− 54.3
90	0.0	−2.5	− 6.0	−10.9	−17.5	−26.8	−38.2	− 53.9
80	0.0	−2.5	− 6.0	−10.9	−17.6	−26.6	−38.5	− 54.3
70	0.0	−2.6	− 6.2	−11.2	−18.0	−27.2	−39.4	− 55.7
60	0.0	−2.7	− 6.5	−11.5	−18.7	−28.3	−41.0	− 58.0
50	0.0	−2.8	− 6.9	−12.4	−19.9	−30.1	−43.6	− 61.6

THE REVERSING VORTEX AND THE COMPOSITION OF VORTICES.

By comparing the perfect vortex ψ_0, of Table 73, with the imperfect vortex ψ_1, of Table 72, it is seen that a reversing vortex, $\psi_1-\psi_0=\psi_2$, added algebraically to ψ_0 will produce ψ_1. This vortex rotates in the opposite direction to the observed vortex and it descends from the clouds to the surface. The radii ϖ_n of these vortices ψ_1, ψ_2, ψ_0, are assumed to be identical. This reversing vortex is equivalent to a system of forces which are operating to retard the imperfect vortex ψ_1 so that it can not reach the perfect vortex ψ_0 in its development. These resisting forces are (1) the simple friction; (2) the internal minor rotations and inertia vortices; (3) the asymmetrical distribution of temperatures so that they do not readily produce vortex motion, but nearly horizontal currents which are much less fully organized than in symmetrical vortices. This method of determining the total forces of resistance at any point may have great value in meteorology; it promises to be-

come a fruitful method of discussing the difficult problems of friction and inertia in the atmosphere.

Instead of deriving the resistance vortex by computing the imperfect and the perfect vortices separately, we can proceed directly from the formulas. If the values of A_2 in the reversing vortex be computed from the values of u_2, v_2, w_2, produced by composition, it is found to be the same as would be obtained by subtracting the constants, $A_1 - A_0 = A_2$, at once.

Imperfect vortex,	Perfect vortex,	Reversing vortex,
$u_1 = -A_1 a\varpi \cos az$,	$u_0 = -A_0 a\varpi \cos az$,	$u_2 = -(A_1 - A_0) a\varpi \cos az$,
$v_1 = A_1 a\varpi \sin az$,	$v_0 = A_0 a\varpi \sin az$,	$v_2 = (A_1 - A_0) a\varpi \sin az$,
$w_1 = 2A_1 \sin az$.	$w_0 = 2A_0 \sin az$.	$w_2 = 2(A_1 - A_0) \sin az$.

The values of $(A_1 - A_0)$ found from u_2, v_2, w_2, respectively, are identical. In other words, by subtracting the constants A_0 in Table 71 from A_1 in Table 70 the values of $(A_1 - A_0)$ will be found which will reproduce the vortex of Table 74, the signs being as there computed. It follows, from this exposition, *that a vortex can be analyzed into its components, or the resultant vortex can be found from its components.* If, on a given level az, the velocities u, v, w, are observed in a vortex whose vertical dimensions are determined thru the a-constant, we shall find values of A which may or may not be in harmony with each other. If we similarly compute the values of A on different levels for the proper radii ϖ_n, their divergence or agreement will permit a discussion of the internal forces that have caused them to change from a given vortex type. Since the land-cyclones are apparently based upon the dumb-bell-shaped vortex, tho it has been much depleted, it yet offers us a method of studying several difficult problems. The Cloud Report contains much data in form for such an application, and it is therefore of interest to consider to what extent the observations, as there discust, are in harmony with this vortex. Since the forces producing the motion in a cyclone are entirely different from those in a hurricane it is not probable that there will be any close agreement. It would leave an erroneous impression to suppose that the ordinary dumb-bell vortex, even if it be defective, is still to be found in the land-cyclone, because the vortex there represented is a concave dumb-bell vortex and not a convex vortex, as already illustrated in the tornado and the hurricane. The ocean-cyclone has been used merely as a transition type between the concave and the convex types of dumb-bell vortices.

A BRIEF HISTORICAL REVIEW OF THE THEORIES OF STORMS.

Cyclones and anticyclones have usually been treated as masses of air with warm and cold centers, respectively, by meteorologists. Two theories stand in contrast to this general view: (1) Dove's theory of the mechanical interference of currents moving in different directions; and (2) Bigelow's thermodynamic asymmetric currents of different temperatures which produce cyclonic and anticyclonic circulations with their centers near the edges of these currents. As Dove's theory deals with long currents it will be proper to recall the exact status of his theory. Dove wrote with much perspicacity for a great period of time, 1827-1873, wherein he was a collector of facts observed in various parts of the world, which were discust in a descriptive manner rather than by a mathematical method. His "Law of Storms," second edition, 1862, translated by Robert H. Scott, is most easily accessible to English readers, and the following references are made to that book. All meteorology is to be classified under thermodynamics and circulation, and a few extracts will make Dove's views plain on both points.

(1) *Thermodynamics.*—This subject is distributed into the cases of circular masses, and of parallel streams.

(Page 18.) If any point in a liquid be heated more strongly than the others, currents arise in it, and the colder particles flow from all sides toward this heated point.

(Page 256.) If two currents, on coming in contact with each other, have altered their paths thru any angle, so that they flow in opposite directions in parallel channels, the following question arises: What conditions will cause mutual lateral displacement after such a state of things as that described is once in existence? The most obvious cause is to be found in the fact that the cold air of the polar current exerts a greater lateral pressure than the warm air of the equatorial current and therefore has a tendency to displace it.

(Page 79.) The equatorial current flows from a warm to a cold, and the polar current from a cold to a warm region. The characteristic differences of these currents may always be traced to their differences in temperature, and to differences in the action exerted by the earth (gravitation) on them in their course.

(Page 83.) As regards the mutual displacement of the currents, I have ascertained, from observations which have been carried on at Königsberg for a long series of years, that the southerly current displaces the northerly in the upper strata of the atmosphere before it does so in the lower strata; while the displacement of the southerly by the northerly takes place first in the lower and afterwards in the upper.

These displacement propositions are, of course, the commonplaces of the thermodynamics of fluids of different temperatures. Unfortunately meteorologists have followed up the central-mass system, to the exclusion of the parallel-current system, in the analytical discussions, and the results have been disappointing. The second equation of motion readily yields central solutions, while the hydrodynamics of the parallel-current systems is exceedingly difficult to work out in a practical form. It is easy to state the general thermodynamic problem, but hard to make applications in the atmosphere. Margules has given several cases for model conditions, particularly under adiabatic transformations, but in the free air adiabatic conditions prevail over such limited spaces before breaking up into minor mixing vortices, that they are not readily transferred to the problems of cyclones and anticyclones. Bigelow has sought to point out some modifications in the thermodynamic formulas, and especially to collect the observations in the several strata up to 10,000 meters, in such a form as to make a beginning in the study of the real thermodynamics of the atmospheric circulation.

(2) *Circulation.*—In his treatment of the circulation of air over the hemisphere and in local cyclones, Dove has not been so happy as in his thermodynamic suggestions. He discusses (1) radial motions toward a center below, and away from a center above; (2) tangential motions around an axis; (3) motions in straight parallel lines; (4) motions to and from the apex of the sector formed by the converging meridians. He is chiefly interested in establishing a "law of gyration," by which the circulation is directed from the south thru west, north, and east. The chief if not the sole application of his thermodynamics of lateral expansion, is in the justification of this rule, but he says:

(Page 175.) When I first published my papers on the winds, I was disposed to refer the law of gyration, as well as the rotary motion of storms, to the mutual interference of two currents of air, which alternately displace each other in a lateral direction A closer examination of the phenomena showed me that the law of gyration depended on more general principles, and that it was a simple and necessary consequence of the motion of the earth on its axis.

He thereby stated the practical effects of the "deflecting force" due to the earth's rotation, but abandoned the lateral displacement theory as regards the formation of storms. Dove's mechanical theory of interference of currents flowing in different directions is stated in many places, and seems to have been derived from his conception of the action of the upper and lower trade-winds in producing hurricanes which form the initial stage in cyclones of the higher latitudes, and are analogous in their formation under all circumstances.

(Page 176.) It was not until later that I was able to supply this deficiency by proving that a cyclonic movement was produced whenever the interposition of any obstacle interfered with the regular change in the direction of the wind, which is due to the rotation of the earth.

(Page 185.) This renders it probable that the primary cause of the West India hurricanes is the intrusion of a portion of the upper trade-wind into that which lies underneath it.

(Page 188.) The interference of a current flowing from east to west with another which is flowing from southwest to northeast must necessarily generate a rotatory motion in the direction opposite to that of the hands of a watch. According to this view the hurricane which advances from southeast to northwest in the under trade-wind represents the advancing point of contact of two currents in the upper strata which are moving in directions at right angles to each other. This is the primary cause of the rotatory motion.

(Page 196.) The upper part of the cyclone will accordingly dilate at once and advance in a direction different from that of the other part. Hence, as a secondary phenomenon, a suction will ensue in the center of the cyclone and, also, a diminution of pressure over the surface of the earth.

In regard to the general circulation, Dove conceives the vertical section as a figure ∞, with the ascending currents *both at the equator and poles*, crossing in the outer limit of the Tropics.

(Page 271.) The upper counter-trade of the Torrid Zone descends at the outer edge of this area; flows into the Temperate Zone; rises again when it comes into higher latitudes; flows back as a polar current in the upper strata of the atmosphere of the Temperate Zone; descends afresh at the Tropics; flows in toward the equator along the surface of the ground as the ordinary direct trade-wind, and at the equator rises again.

(Page 221.) The West India hurricanes are due to the interference of lateral cross-currents with the upper trade-wind on its return from the equator, portions of which, being forced to enter the lower strata of the atmosphere, meet with a constant wind, moving in a direction opposite to their own and thus produce a cyclone. Outside the trade-wind area the upper current descends to the surface of the earth, and is predominant there in different districts at different times, while the under-current in the opposite direction is not constant. Here, then, we shall find that the conditions of interference will be constantly presented, but the currents will be directly opposed to each other so that they will only check each other's progress.

It is evident that Dove's theory of interference and obstruction for the formation of cyclones induced him to describe a circulation over the hemisphere which is partially correct in the temperate zones, but erroneous in the polar zones. Since the ordinary canal theory of the circulation with a poleward current from the equator to the pole in the upper strata, and a return current from the pole to the equator in the lower levels (Ferrel, Oberbeck), could produce no currents of different temperatures on the same levels, whether high or low, therefore in the Cloud Report I described the "leakage current," escaping from the Tropics in certain longitudes, as on the western side of the Atlantic high area, by which warm currents are thrown into the United States from the south to meet the cold currents from the north in the lower strata. The theory of interference and obstruction was rejected, and a theory of the asymmetric cyclone and anticyclone described, depending on the lateral interpenetration of the warm and cold masses, thus using the key which Dove threw away, and which is evidently the only key to unlock this problem. Compare Cloud Report, Charts 20–35, p. 606–609, 612, 615–633, and numerous papers in the MONTHLY WEATHER REVIEW.

Ferrel sought the explanation for cyclones in a cold- or warm-centered vortex, as did Guldberg and Mohn, Oberbeck, and others, using different solutions of the second equation of motion, but the source of heat energy at the center is so inconsistent with the observed distribution of the temperature, that the symmetrical cyclone was abandoned by me in favor of the asymmetrical cyclone and anticyclone. The difficulty in making progress with this view was due to the fact that for several years following 1898 reliable temperature observations in the *free* upper strata were not available as they have since become thru the reports of balloon and kite ascensions. Those that have been obtained show that the asymmetric temperature distribution found at the surface presists to the top of the cyclonic disturbance of the eastward drift in substantially the same relations, so that the problem can now be resumed. The preceding papers of this series, as well as the "Studies on the Thermodynamics of the Atmosphere," 1907, are simply introductory to the cyclonic problem, which will no doubt require much careful mathematical study.

It is easy to state a theory in general terms of the action of warm and cold masses on each other in horizontal directions, but to pass thru the thermodynamic equations to the dynamic stream-lines in so complex a system of flow, involving hydrodynamic conditions which are neither simple nor constant, is a work of extreme difficulty. Hann found evidences that the temperatures in the levels above the surface layers did not conform to the central or symmetrical theory of Ferrel, but he believed that the change of temperature, from warm to cold in cyclones, for example, was a dynamic effect such as is produced in ascending currents. The asymmetric theory calls for no such dynamic action to produce thermal effects, but, on the contrary, it takes the observed existing thermal conditions, and finds from them the necessary cyclonic dynamic circulations. In the preceding papers of this series we have been able to trace certain tornadoes and the hurricane to the simple dumb-bell vortex, but in the ocean-cyclone there is evidence that the vortex is becoming very imperfect, so that the dumb-bell vortex must be greatly modified to be applicable to the ocean-cyclone, and so much the more, to the land-cyclone. One of the chief labors of the Cloud Report, 1896–97, was to compute the radial component of the velocity, u_2, from the cloud observations, and this result, Table 126, p. 626 of that report, will be employed in the following paper on the land cyclones to bring out some of the leading features of this difficult problem.

DEFICIENT HUMIDITY INDOORS.

By F. H. DAY, B. Sc., Demonstrator of Physics, McGill University.
Dated Montreal, December 21, 1908.

In view of the republication[1] of Prof. R. DeC. Ward's observations on the relative indoor and outdoor hygrometric conditions in the neighborhood of Boston and Cambridge, Mass., it is interesting to compare these with some similar investigations carried on in Montreal during the winters of 1906 and 1908 by Dr. T. A. Starkey and Dr. H. T. Barnes,[2] of McGill University. This work was undertaken in order to determine the effect of a successively dry atmosphere on the human organism—a question of great moment in Canada, especially in those parts where during the winter months the heating of the houses necessitates the heating of the indoor atmosphere, thereby causing a tremendous drying of the air. And this is the first condition for the difference between the air in the two places. Professor Ward was working with an indoor and outdoor difference of about 35° F., while in Montreal this increases to a difference of from 70° to 100° F. during the colder months. Knowing that if we warm a given quantity of air completely saturated with water vapor at the initial temperature, it no longer remains saturated, we can readily see what an enormous change in the relative humidity is entailed by heating outside air at a temperature of 0° F., or below, to a higher temperature.

As a danger to the health caused by this excessive dryness, Professor Ward mentions the strain put upon the body going out from a high temperature and very dry atmosphere into an atmosphere low in temperature and comparatively high in humidity. Starkey and Barnes find another and quite as serious a danger in the direct effect of the dry atmosphere itself. This condition is well borne out by some striking illustrations. To quote from this paper:[2]

The action of a dry atmosphere affects primarily the mucous membranes lining the respiratory tract, chiefly that of the nose, the throat, and the bronchial tubes. It is a peculiarly mechanical irritant, resulting in a condition of congestion of the mucous membranes before mentioned. If this irritation be continued for any length of time these swollen membranes with difficulty regain their normal state. We have thus all the conditions favorable for a chronic catarrh, and this chronic condition being established we get all the typical symptoms of nasal-pharyngeal

[1] Monthly Weather Review, September, 1908, 36: 281.
[2] Trans. Roy. Soc. Can.

catarrh, spreading often to the eustachian tubes communicating with the little ear. When considering the effect of an irritation due to dry air on a mucous membrane already irritated or congested by some disease, e. g., tuberculosis, bronchitis, pneumonia, etc., none can deny for a moment the deleterious results that necessarily follow such an added irritation. Or, if the lungs are normal and healthy and the mucous membrane lining them gets in an irritated state, the conditions are then favorable for the grafting on of some disease, e. g., most marked of all, tuberculosis. If other mechanical irritants besides that produced by dry air can be the starting point of predisposition of such a disease, why not that produced by dry air?[3]

The following are two of the cases recited:

Case 1.—A. B. arrived in Canada late in the year, and during the winter suffered greatly from congestion of the throat and nose and to a less extent of the bronchial passages. The air of the room which he occupied was suspected, but chemical analysis showed its composition to be fairly good, CO_2 was 0.08 per cent. The air in the room where he spent most of the day showed CO_2=0.07 per cent, but the symptoms of congestion never developed there, consequently vitiation by excess of CO_2 could not account for the trouble. On testing the relative humidity it was found to be from 40 to 50 per cent. The symptoms of congestion always disappeared rapidly when the individual went out of doors. Keeping the windows open regularly prevented the congestion.

Case 2.—The case of a family in which there were five children, three boys and two girls, ranging from three to ten years. They had returned to town, after a stay in the country during the summer. The boys quickly began to lose tone as the winter came on. They all exhibited congestion of the nose and throat of a chronic nature. The two little girls continued well. It was found that the girls slept in a room where the windows were kept open night and day, but not so the boys. Chemical examination in the different rooms showed no material increase of the CO_2 or the presence of other deleterious constituents. The relative humidity was 40 per cent. In the boys' room a minimum of 38 per cent was obtained.[4] In the girls' room the relative humidity averaged from 50 to 55 per cent. Fresh air was admitted by open windows to the boys' room and they showed signs of improvement immediately, and are now quite well.

From the evidence of throat and nose specialists in Montreal there would seem to be little doubt as to the deleterious action of a dry atmosphere upon the human body,

In Table 1 we have a comparison of the indoor and outdoor relative humidities, with the temperatures for the colder months:

TABLE 1.—*Average winter temperatures and humidities, indoors and outdoors, at Montreal, Canada.*

	October.	November.	December.	January.	February.	March.
Average relative humidity, outdoors	87.8	86.7	79.2	78.1	79.2	80.3
Average temperature, indoors, in degrees F.	64.0	64.0	65.0	66.0	66.0	65.0
Average relative humidity, indoors, windows closed	58.0	53.0	46.0	41.0	42.0	45.0
Average relative humidity, indoors, windows open	66.0	61.0	58.0	57.0	57.0	58.0

These results agree in differences very well with those obtained by Professor Ward. But the indoor percentages are much higher than one would expect, considering the range of temperature. As is shown later in this paper, this is undoubtedly due to the type of instrument used to measure the humidity. The stationary form of wet-bulb and dry-bulb hygrometer was used, and comparisons with the Regnault and the chemical method showed the instrument to be wholly inadequate for the lower readings. As an illustration of this, in one of Starkey and Barnes' observations the Regnault hygrometer gave a dew-point of 3.75° F. for the air in the laboratory during a a cold winter's day. The relative humidity, calculated from this dew-point, is 6.25 per cent. But the indications of the wet-and-dry hygrometer of the stationary type were interesting. The dry-bulb registered 69° F., and the wet-bulb 57° F., showing a difference of 12°. This gives a relative humidity of 45 per cent.

A comparison was made with a chemical hygrometer, and the following results obtained:

TABLE 2.—*Simultaneous determinations of relative humidities by two methods.*

Serial number.	Stationary wet and dry-bulb.	Chemical analysis.
	%	%
1	78.0	70.5
2	71.0	71.0
3	53.4	34.7
4	55.1	35.0
5	52.2	36.5
6	52.2	36.5
7	54.0	36.0
8	53.0	28.5
9	38.8	30.5
10	39.0	29.0

Following is the discussion of the table:

The first six observations were taken on different days at very irregular intervals, extending over six weeks in the spring of 1906. The wet- and dry-bulb thermometers were suspended in the middle of the laboratory, where only a slight current of air was obtained. The disparity in the results here is extremely striking, and from the figures obtained one can not deduce any correction applicable to the wet- and dry-bulb instrument. Where the humidity is about 70 to 80 per cent the results apparently are not very far from the average condition of the humidity, but with a fairly still atmosphere and a very low percentage of moisture the results vary tremendously.

The last four observations, namely, Nos. 7, 8, 9, and 10, are interesting, being all taken on the same day, 7 and 8 being taken in the morning at a two-hour interval, the wet- and dry-bulb instruments being placed under still air conditions as above mentioned. Here the discrepancy is about 20 per cent. In Nos. 9 and 10 observations were taken in a very marked draft of air, the instruments being placed in the drafts from three large, open windows, and one would not be very far short of the mark by saying that the conditions were almost identical with those in the open. The evaporation from the wet-bulb had thus free play and would be practically at its maximum.

The relative humidities under these conditions correspond fairly closely with those obtained by exact chemical analysis. It is, of course, as one would expect, that when full play is given to the evaporation the record ought to be nearer the truth than when the instrument is placed in a still atmosphere and the rate of evaporation is interfered with to a large extent. But one can easily see from the last set of observations that no figures of correction are possible, because the rate of evaporation depending so exactly upon the movement of the air, any interference with the latter would necessarily throw the results out a great way from the truth.

The instrument used in this case, as is observed in a succeeding paper by the same authors,[5] had a rather small spherical bulb and a comparatively long wick. Comparisons were made of different forms of the stationary wet-and-dry instruments by altering the size of the thermometer bulbs, using different kinds of wicks, changing the position of the reservoir, varying the temperature of the feed water, and using air currents of different velocities. The effect of an air current is readily shown by the following results, where two instruments are used, one with a large bulb and one with a small:

Instrument No. 1: difference in temperature between bulbs before supplying air currents, 14.9° F.; difference in temperature between bulbs after supplying air currents, 18.8° F.

Instrument No. 2: difference in temperature between bulbs before supplying air currents, 16.2° F.; difference in temperature between bulbs after supplying air currents, 20.5° F.

These observations were taken on a day when the Regnault dew-point hygrometer gave a relative humidity of a little over 6 per cent. No. 2 in the last reading gives approximately this same value. At the same time it was established that it makes little difference whether the rate of air current be fast or slow, provided that there is a perceptible rate.

A sling-psychrometer was obtained and its readings compared with the Regnault. The type of instrument was such that it was necessary to bind a moist wick above the bulb as

[3] By "dry air" is here meant air artificially dried. The benefit of a dry climate to patients suffering from tuberculosis is well known. We know of no evidence to show that the same benefit or any is derived from artificially dried air.

[4] These measurements were made with a stationary type of wet- and dry-bulb hygrometer. Later measurements indicate that such instruments give far too high values of the humidity for a dry atmosphere.

[5] Trans. Roy. Soc. Can.

a reservoir, to prevent the bulb drying before the minimum reading was obtained. This was undoubtedly due to the spherical form of the bulb, causing it to be very insensitive. Also the reservoir had to be protected by tin-foil, in order to prevent a too great lowering of the temperature of the feed water, due to excessive evaporation. Fairly constant readings were obtained.

TABLE 3.—*Comparisons of Regnault's and the sling psychrometer.*

Type of instrument.	Date.	Temperature.			Relative humidity.	Dew-point.
		Outdoor.		Indoor.	Indoor.	Indoor.
		Max.	Min.			
		° F.	° F.	° F.	%	° F.
Sling	Feb. 4, 1908	−3.5	−20.0	64.9	4.5	
Regnault	Feb. 4, 1908	−3.5	−20.0	66.2	5.2	−2.0
Sling	Feb. 5, 1908	−6.4	−20.6	62.6	2.8	
Regnault	Feb. 5, 1908	−6.4	−20.6	63.1	5.1	−5.0
Sling	Feb. 8, 1908	2.0	−8.0	68.0	5.8	
Regnault	Feb. 8, 1908	2.0	−8.0	69.0	5.5	−1.0
Sling	Feb. 11, 1908	30.0	15.8	68.5	10.7	
Regnault	Feb. 11, 1908	30.0	15.8	66.2	5.2	−2.0
Sling	Feb. 14, 1908	39.8	34.2	73.3	24.4	
Regnault	Feb. 14, 1908	39.8	34.2	73.5	21.9	−32.1
Sling	Feb. 15, 1908	35.0	29.5	71.2	26.0	
Regnault	Feb. 15, 1908	35.0	29.5	71.2	25.2	−34.0

The first two sets of observations were made without the tin-foil protection over the wick, the last four with it. The water feeding down was in the first case cooled before coming into the bulb and this gave too low indications.

The effect of the low outside temperature is well shown in the excessively low humidity inside. It was noticed also that in some cases hoar frost was deposited on the Regnault instrument instead of dew. Speaking of this, Doctors Starkey and Barnes remark—

> An interesting question arises here as to the deposition of moisture in the form of vapour or hoarfrost. The vapour pressure of hoarfrost is considerably smaller than that for supercooled [subcooled] water, giving results 25 per cent too high at 0° Fahrenheit. We think there is no question that for very low temperatures of the dew-point we got in all cases hoarfrost.

In all these observations Glaisher's tables were used, with extrapolations for the lower values. During the autumn of the present year the writer, using the type of psychrometer[6] employed by the United States Meteorological Department [the Weather Bureau] and the tables accompanying it, made some comparisons with the chemical hygrometer, obtaining very good results, even at the lower values.

TABLE 4.—*Comparisons of methods.*

Date.	Chemical hygrometer	Sling psychrometer.	Stationary psychrometer.
1908.	%	%	%
November 10	49.9	48.0	58.0
November 14	34.0	34.0	48.0
November 21	32.0	24.0	34.0
November 24	41.6	42.2	47.0
December 2	25.3	26.0	37.0
December 4	20.7	20.0	32.5

The agreement here [between the chemical method and the Weather Bureau method] is as close as could be expected. At least, there is no marked departure from the chemical readings at the lower humidities. The stationary psychrometer is seen to depart very considerably as the humidity falls.

Professor Ward, in his paper, suggests the placing of water pans either over the furnaces for hot air heating or over the steam coils in steam-heated houses. Doctors Starkey and Barnes considered this matter in concluding their paper.

> Methods have been devised for supplying moisture to the air of houses, but a few figures to show the amount of moisture required to bring the air up to a normal healthy condition will be fourd to be somewhat, discouraging (as far as the efficacy of pans go). Thus in an ordinary sized dwelling house, when due allowance is made for the amount of air required by each person per day, something like 33 gallons of water must be evaporated daily to keep the air at a relative humidity of 75 per cent. Other difficulties arise when this is accomplished. Condensation takes place on the windows when the air temperature outside is very low. Experience has shown that this commences at a humidity of about 40 per cent. We are inclined to think that much could be accomplished by maintaining the humidity, even at this latter figure, and that the question should be earnestly considered in order to improve the general health of the large proportion of the people who spend the greater part of their lives in artificially heated buildings.

Some later measurements by Starkey and Barnes during the coldest weather in the winter of 1907–8 showed a relative humidity of only 3.5 per cent in one of the university buildings. That this is attained also in private dwellings and schools generally seems likely, unless some means are taken to introduce moisture. The want of attention to this fact is responsible, no doubt, for much headache and general lowering of the vitality of scholars and others in the winter time who have to spend this time indoors. A steam jet seems to be about the only way of correcting for the deficient humidity during the coldest weather. Pans placed about a house are but as a drop in a bucket and have but little influence. Steam humidifiers are now available in Montreal for private houses employing the hot water system of heating, which system offers the most difficulty to obtain adequate moisture. Wherever these have been installed great benefit has resulted in general health. An actual saving of fuel also results from the lower temperature necessary in order to maintain a comfortable living room.

NOTE BY THE EDITOR.

One comment on this instructive article on humidity indoors comes naturally to the minds of those who have worked for many years on the problem of determining the humidity of our atmosphere, viz, that the use of the wet-bulb in still air has long since been abandoned by meteorologists in Germany and America, altho it continues to be used in countless private and public buildings. The whirled psychrometer was introduced by Arago about 1830, and the ventilated psychrometer by Belli in the same year; the equivalent sling psychrometer had been used by Saussure in 1786, and by Espy from 1829 onward. The complete theory, the formulas, and tables for the use of the cylindrical wet-bulb with a specific rate of ventilation (6 meters per second) was prepared by Ferrel[7] in 1885. Equivalent formulas and tables have also been prepared by Grassmann, Ekholm, and others. The instrument, its method of use, and the tables for reduction must all be adapted to each other. It is improper to use Glaisher's tables in reducing the readings of the ventilated psychrometer or Ferrel's tables in reducing the still psychrometer. The formula for the cylindrical bulb necessarily differs from that of the spherical bulb, on account of diffusion, radiation and ventilation, rather than on account of sensitiveness, since we only read when the temperature has become stationary. Assmann's ventilated psychrometer is the most convenient for station work, but more expensive and less portable than the sling psychrometer; but these and Arago's whirled apparatus all agree most closely with the dew-point and the chemical methods when the observations are carefully executed.

The tables of vapor pressure, at and below freezing, differ according as the evaporating surface is solid ice or subcooled water.[8] Generally, the table for ice must be used, but not necessarily always.—*C. A.*

[6] This type of sling hygrometer has thermometers with long cylindrical bulbs. These are more sensitive than the bulbs on the sling used by Starkey and Barnes, on account of having a greater surface to the volume of mercury enclosed.

[7] See Ann. Rep. Chief Signal Officer, 1886, p. 232–259.

[8] See Smithsonian meteorological tables, Washington, 1907.

VELOCITY OF FALLING RAINDROPS.

In the American Meteorological Journal for September, 1887, **4**:207, the late Prof. Henry Allen Hazen opposes the idea adopted by Prof. Joseph Henry and many others, that the gust blowing outward from a thunder-storm may be due to the air driven down by falling raindrops (in addition to the descent due to the density of the air cooled by the evaporation of the falling drops). The question of the velocity of the falling drop is therefore important in this connection, and has been newly considered by Dr. T. Okada,[1] of the Central Meteorological Observatory, Tokyo, Japan.

Altho in nature we see a rapid series of changes going on by which large falling drops break up into small ones whose diameters are in the ratio 1:2:4:8, and altho we do not often observe the union of small drops into larger ones, yet Okada adopts the idea worked out mathematically in W. H. Besant's Treatise on Dynamics, 3d edition, 1902, p. 78, that the falling drop receives continually accessions proportional to its surface area; he also adopts $C = 0.204$ as the constant for the air resistance and deduces the following table of resulting velocities in meters per second.

Table 1.—*Velocities of falling raindrops.*

Distance fallen.	Diameters of drops.			
	1 mm.	2 mm.	3 mm.	4 mm.
Meters.	*M.p.s.*	*M.p.s.*	*M.p.s.*	*M.p.s.*
1,000	3.1	3.5	4.0	4.4
1,500	3.6	4.0	4.4	4.8
2,000	4.0	4.4	4.8	5.1
2,500	4.4	4.8	5.1	5.4
3,000	4.8	5.1	5.4	5.7

—*C. A.*

WIRELESS TELEGRAPHY IN THE SERVICE OF MODERN METEOROLOGY.

RESULTS OF INVESTIGATIONS MADE DURING A TRANSATLANTIC VOYAGE IN AUGUST, 1908.

By Dr. P. Polis, Director of the Meteorological Observatory of Aachen (Aix-la-Chapelle). Dated Aachen, October 22, 1908.

[Translated by C. Fitzhugh Talman, Librarian, Weather Bureau.]

The first attempts to utilize wireless telegraphy for the benefit of the weather service were undertaken in 1904 by the London Daily Telegraph, and led to a discussion of the subject at the International Meteorological Conference at Innsbruck, 1905. The matter was brought before the Conference and a report on the subject presented by the writer of this article. The question was referred to the International Meteorological Committee.

Experiments in this line have likewise been carried on by the British Meteorological Office, under the direction of Doctor Shaw, with the use of observations taken on board British warships. The United States Weather Bureau, also, made use some years ago[1] of such reports from vessels on the Atlantic, to enlarge the scope of its weather maps.

Last year I paid a visit to the United States, in the course of which I made some preliminary investigations regarding the transmission of weather reports at sea. These investigations were continued on a larger scale in August of this year during a voyage to America and return on board the *Kaiserin Auguste Viktoria*, from the 7th to the 27th of August. Not only were weather telegrams sent from ship to ship, but wireless reports containing meteorological data were also received from land stations in Europe and America; the former viâ the Marconi station at Clifden, the latter viâ Cape Cod. All steamers passing within range of the *Kaiserin* were requested to communicate meteorological observations taken during the preceding twenty-four hours. These observations were secured thru an understanding most obligingly entered into by the other steamship companies with the Hamburg-American Line; and the telegrams were transmitted free of cost by the Marconi company. These telegrams contained the position of the ship, time, height of the barometer, temperature of air and water, and wind direction and force. Generally as many as five reports from vessels were available daily. Moreover observations from stations on the British and French coasts were forwarded daily from the observatory of Aachen, by way of the Marconi station at Clifden, for four days after the ship left Cherbourg, i. e., to a distance of about 3,000 kilometers (1,864 miles) from the British coast. The telegrams, tho in cipher, were transmitted to this distance with absolute accuracy. A copy of one of these telegrams, that of August 11, is given below, accompanied by the translation:

Compagnie de Télégraphie sans Fil.

11 August 1908. Marconistation *Kaiserin Auguste Viktoria.*

Aufgabestation: Aachen.

Aufgenommen 43° N. Br. 45° 37′ W. L. 1640 Meilen von Scilly entfernt.

An POLIS:

62613 263 63126 64526 70928
68930 69532

Translation.

Aachen, 762.6, 13°, WNW., 3; Stornoway, 763.1, WNW.; Malin-Head, 764.5, WNW; Valencia, 770.9, NW.; Scilly, 768.9, NNW.; St. Mathieu, 769.5, N.

The Central Office of the United States Weather Bureau, at Washington, very obligingly furnished, at my request, observations at stations on the American coast for the last days of the outward journey and the first two days of the return journey, thru the Marconi station at Cape Cod.

The material received was brought together in the form of a weather map, (see Chart IX), and it was found possible to make a map every day on both the outward and the return journey. Thus on the weather map of August 11 (Chart IX, fig. 2), when wireless telegrams from Clifden were still being received at longitude 45° west, observations from the French and British coasts were charted, and there were also five observations from vessels. The map shows a high-pressure area extending from France to the Azores, a low near Iceland (see Chart IX, fig. 1), and a second low in the neighborhood of the Newfoundland Banks. The latter moved eastward and crost the track of the *Kaiserin* in the following night, bringing cloudiness, rain, and strong southwest winds. The weather map of August 22 (Chart IX, fig. 4), made on the homeward journey, extends from eastern America to 30° west longitude. It shows the state of the weather for a distance of 800 miles from the *Kaiserin*, as it was possible to utilize the observations of several west bound ships. This map shows a depression between 40° and 30° west longitude, in which the steamers *Kronprinzessin Cecilie* and *Germania* had stormy west winds. This depression moved eastward, while a high-pressure area accompanied the *Kaiserin* from the United States as far as the middle of the Atlantic Ocean.

[1] Journal of the Meteorological Society of Japan, August, 1907, p. 1.

[1] The Weather Bureau work in wireless telegraphy began in January, 1900, when R. A. Fessenden was employed to carry out the instructions of the Chief of the Bureau. The development of the Weather Bureau system was subsequently relinquished; but the receipt of daily wireless messages from ocean vessels for use in compiling weather maps and forecasts began December 3, 1905. (See Monthly Weather Review, 1906, **34**: 609-10.) Before July 15, 1902, the Marconi station on Nantucket was transmitting, via Nantucket Shoals Lightship, the regular Weather Bureau daily forecasts to such Cunard Line steamers as requested it.

The current condition of our experience is summarized in the Annual Report of the Chief of Bureau, which will appear in our Annual Summary for 1908.—*C. A.*

In addition to the daily determination of the weather situation and the making of weather charts, certain other meteorological investigations were carried on; viz, regular observations of temperature and humidity with the aspiration psychrometer. These had the remarkable result of indicating an excessive dryness of the air in the presence of a high-pressure area. The following observations were made on August 21:

Time	Latitude, North.	Longitude, West.	Air temperature.	Absolute humidity.	Relative humidity.	Water temperature.
	° ′	° ′	°C.	Mm.	%	°C.
8 a. m.	40 26	67 21	18.3	9.1	52	18.4
12 noon.	40 38	65 34	21.0	7.6	30	25.3

From the above it may be seen that on that day the air was exceedingly dry, both with a low and a high water-temperature. The mighty reservoir of the Atlantic Ocean was almost without effect on the condition of the air; and the explanation of this fact is to be found in the strong descending currents of the high-pressure area, an explanation confirmed by the extraordinary clearness of the air on that day. These observations were an indication that the *Kaiserin* was not running into the low to the eastward. (See Chart IX, fig. 3.)

On August 27, just before we entered the English Channel, the weather map was finished by about 1 p. m. On this day a severe cyclonic storm lay over the North Sea. About three hours were required for the transmission of the telegrams from the observatory at Aachen, by way of the Marconi station at Crookhaven.

Thus for the first time during the entire voyage of a steamer, have the surrounding weather conditions been followed and weather maps made on the basis of direct observations transmitted by wireless telegraphy from both ships and shore stations. Also, both on the outward and home journey, so long as the *Kaiserin* was in communication with the English coast observations were forwarded from the ship to the observatory at Aachen. The shortest time of transmission for the latter message was 2 hours and 45 minutes.

At a meeting of the administrative board of the Public Weather Service, held at Hamburg October 1, the use of wireless telegraphy in meteorological work was the subject of a lively discussion, and the author laid before the meeting, at which were present representatives of the Imperial Ministry of the Interior, the Post Office, and the Ministry of Marine, both the telegrams received during the voyage and the original weather maps made on shipboard, together with the "Internationale Dekadenberichte" [of the Deutsche Seewarte] for August. A special committee was appointed, charged with making preparations for a further investigation of this subject. The committee is composed of a representative of the Deutsche Seewarte, the Director of the Royal Prussian Meteorological Institute (Doctor Hellmann), Director Polis of Aachen, and representatives of the Hamburg-American Line and the North German Lloyd Company.

To what extent wireless weather reports from the ocean would be of service to practical meteorology in Europe only the future can determine, but that they would be of great value can hardly be doubted. This year's investigations at sea have at least proven that the transmission of such reports is safe and sure, and also that it is feasible to make [daily synoptic] weather charts on the ocean itself.

In connection with the above paper it is only proper to state that some of the European meteorologists are not so sanguine as Doctor Polis regarding the benefits to be derived from wireless reports, whether for use on shipboard or for the land forecasts of western Europe. An especially pessimistic view of the matter is exprest by Dr. E. Herrmann, of the Deutsche Seewarte, in the nautical magazine Hansa, of September 26, 1908. The experience of the British Meteorological Office in dealing with wireless reports from naval vessels is, on the whole, encouraging, but emphasizes the necessity of a careful control of the barometer readings thus received. The investigations of Mr. Ernest Gold appear to show that barometer readings on board ship are generally too low in strong winds.[2]

Beginning with February, 1909, a series of tests of the efficiency and utility of wireless weather telegraphy, extending over a period of three months, will be carried on jointly by the Meteorological Office and the Deutsche Seewarte. It is understood that arrangements have been made whereby all the principal transatlantic steamship lines will forward wireless weather reports to the above-named offices. The results of these experiments are to be presented to the International Commission on Weather Telegraphy, which meets in London June 21, 1909.—*C. F. T.*

REMARKABLE SNOW-STORM AT GRAND HAVEN, MICH.

By C. H. ESHLEMAN, Observer. Dated Grand Haven, Mich., November 20, 1908.

A very remarkable snow-storm occurred at Grand Haven, Mich., on November 14, 1908. Between about 1 a. m. and 6 p. m., 12.5 inches of snow fell. This is by far the heaviest 24-hour fall in November on record here, and was exceeded only once in any other month, viz, on January 22–23, 1898, when 13.6 inches fell. The snowfall records at this station began with the season of 1889–90 and extend to the present time, except for the period July 1, 1903, to August 1, 1905, when the regular Weather Bureau station had been discontinued. The rate of fall in the recent snowfall was very large, the average rate from about 3 a. m. to 1 p. m. being about 1 inch per hour.

But remarkable as the snow was in its amount, it was no less remarkable for its limited and well-defined extent. It covered a strip of country that extended inland only about 15 or 20 miles, and along the lake for a distance of about 70 or 80 miles. The greatest falls occurred 6 or 7 miles from the lake, beginning a little south of Grand Haven, and extending northward 20 or 30 miles. Along this line depths of 16 to 18 inches were reported. Beyond the limits first mentioned the amount decreased rapidly, so that 15 or 20 miles farther on the depth was rarely more than 1 or 2 inches, and in the majority of cases even less. Fishermen who were out on the lake 15 or 20 miles from shore report that very little snow occurred there.

Grand Haven appears to be located about midway between the northern and southern extremities of the area. At Ludington and St. Joseph, to the northward and southward, respectively, but beyond the limits the amounts were very small. None of the other Weather Bureau stations in the Lake region reported more than 1 or 2 inches, some of them only a trace.

It may be said that the particular section covered by the snow has a nearly southwestward exposure to the lake, and beyond the limits defined the trend of the shore changes somewhat. The general direction of the winds over Lake Michigan during the storm was southerly to westerly. At Grand Haven, however, the direction was somewhat variable, being southeasterly most of the time, occasionally shifting to southwesterly. About noon it shifted to westerly, and after that the rate of fall diminished gradually.

It is possible that the intermixture caused by the varying wind direction, of masses of air having different moistures and temperatures was a potent factor. There were no marked local changes in temperature or pressure. The phenomenon appears interesting as an extreme instance of the effect of a peculiar lake exposure on the weather of particular localities.

[2] "Comparison of ships' barometer readings with those deduced from land observations; with notes on the effect of oscillatory motion on barometer readings." (Q. J. R. Meteor. Soc., April, 1908, p. 97–108.)

It may be mentioned also that on November 13, the morning before the deep snow, something similar, altho on a much smaller scale, occurred. Grand Haven had 2.4 inches of snow and Grand Rapids only a trace. On both mornings the snow began soon after midnight, and the general distributions of pressure were somewhat similar. In both cases the local wind direction was somewhat variable, but on the 13th the heavy snow occurred, with a light northerly wind.

TORNADOES IN WISCONSIN, NOVEMBER 25, 1908.

[Extract from the Monthly Climatological Report, Wisconsin Section, November, 1908.]

During the evening of November 25 a well-defined tornado occurred at Stevens Point, Wis. The most remarkable feature of the storm is the season during which it occurred. Altho Wisconsin is visited by tornadoes on an average of about three each year, this is the first one recorded during the colder half of the year. On September 29, 1881, there were tornadoes at Wautoma, Waushara County, and at Montana, Buffalo County, the one at the latter place causing great destruction to property and injuring twelve people. Practically all other tornadoes reported in the State since the establishment of the Weather Bureau have occurred during the months of May to August.

From the 17th of November, this year, until the 26th the temperature was considerably above the normal in Wisconsin. On the morning of the 23d an atmospheric depression was over the Panhandle of Texas. This storm moved rapidly northward across western Lake Superior, and was closely followed in nearly the same track by another and more energetic plateau storm which was central over western Wisconsin at 7 p. m. November 25.

The tornado on this evening began shortly after 7 o'clock in the town of Grant, Portage County, about 7 miles east of Grand Rapids, and moved northeastward to Stevens Point and slightly beyond, a distance of about 12 miles. The path of the tornado varied between 20 and 300 feet. Owing to the darkness, only those in the country saw the funnel-shaped cloud which is usually observed. One man at Stevens Point lay within 50 feet of the path of the storm as it past, but he could not distinguish any particular shape. Another man saw it from a distance of about 200 yards as it crost the street. To him it appeared to be a light colored mass of clouds.

About 3 miles from where the tornado was first observed in the town of Grant, Portage County, Charles Laufer, sr., was killed by falling timbers when his house was destroyed and Mrs. Laufer and her daughter were severely injured. The house and all the furniture were broken into small pieces and distributed a quarter of a mile along the path of the storm. Several other buildings were completely destroyed in the open country, and in the village of Meehan.

At Stevens Point many buildings were wrecked and other damage done, but as the storm did not pass thru the residence district no lives were lost. The damage to buildings and other property in Stevens Point is estimated at $100,000.

Mr. G. L. Culver, cooperative observer at Stevens Point, who furnished a detailed report of this tornado, says: "The wind had been blowing all morning from the northeast and east, but swung around later in the day to the south and at 7 o'clock in the evening it was blowing steadily from the southwest, but not very strong. The tornado occurred at 7:30 p. m., and at 8 p. m. the sky was clear and there was scarcely any wind. The next morning, however, the wind was blowing strong from the west and southwest, with clouds all day. * * * At some points the width of the path was no more than 20 to 25 feet, as in one place it took a section of the lattice fence 20 feet long; at other places the effects of the whirl was seen for about 75 yards in width."

During the same evening, but about thirty minutes earlier, another severe storm past about 2 miles west of Rudolph, in Wood County, and extended north-northeast to Junction City, Portage County. Elisha Hook, a farmer living near Junction City, was severely injured and died two days later, and six others were injured.—*W. C. Devereaux.*

SEVERE WIND-STORMS IN OHIO, AUGUST 12 AND 17 1908.

By J. WARREN SMITH, Section Director. Dated Columbus, Ohio, September 26, 1908.

On August 12, considerable damage was done in LeMoyne, Wood County, by high wind. A well-defined funnel-shaped cloud was observed. It moved in a northeasterly direction, and the path of greatest damage was about 100 feet in width and about 1 mile in length. One barn was blown down and a buggy was overturned. Fruit trees and fences suffered, but the total damage was not great. The storm occurred about 5 p. m.

During a thunder-squall at 2:40 p. m. on August 17, two spans (or sections) of a bridge across the Muskingum River, between Philo and Duncans Falls, Ohio, were blown from the piers into the river. Moderate damage was done to fruit and shade trees by the wind, the hail injured growing crops and lightning struck a number of houses. The squall was accompanied by 0.79 inch of rain.

The path of greatest destruction was about 400 feet wide and the estimated damage $4,000. Mr. Louis Hardtla, cooperative observer at Philo, has sent a very complete drawing of the locality and a photograph of the bridge, taken thirty minutes after the damage was done. He states that the damage was not done by a tornado, but by a straight-line squall. The path of the squall could be traced from about 3 miles west of Philo to three-fourths of a mile east; hail extended farther in both directions.

The river flows almost directly east for several miles above Philo, and then turns to the south opposite the village. It narrows down considerably at this point and runs between bluffs about 200 feet in height. A house was blown down a short distance above the bridge. The observer was injured by lightning.

SEVERE WIND-STORMS IN NEW MEXICO AND OKLAHOMA.

W. W. Chilton, of Clayton, Union County, N. Mex., reports that severe winds visited this region during the night of November 5, 1908, doing damage to the amount of $40,000 to $50,000 and causing the death of three persons. From his report it appears that a hard, straight wind began to blow at Clayton at 8:15 p. m. of the 5th of November, and rapidly increased in force until at 8:30 p. m. an extra hard puff occurred, which resulted in much damage to the large 2-story brick court-house and to other houses and stock. The report states that the whole upper story of the court-house was blown off and the walls cracked.

Simultaneously with the destructive puff in Clayton, occurred a similar puff 2 or 3 miles west of Clayton. Here one man was killed, perhaps by falling timbers, and several houses were destroyed.

After this hour the wind is reported to have died down to "a fairly hard ordinary blow," which continued until about 2 a. m. of November 6, when it again blew quite hard; then came an extra hard "streak" which, passing 2 or 3 miles east of Clayton, destroyed several buildings and killed two persons. About this same time, 2 a. m., a similar hard blow destroyed a number of buildings at a point a little west of Kenton, Okla., which is almost due north-northeast of Clayton, N. Mex.

Mineral, Okla., was also visited by a severe wind which resulted in the death of a man. All five of these blows are reported to have been south winds.

Mr. Chilton, in his report, expresses the conviction that these winds must have been tornadic whirls, the first one, at Clayton, having a path from 20 to 100 yards wide; but he is careful to state that the characteristic funnel-shaped cloud was not observed, perhaps, as he says, on account of the darkness of the night. Mr. Chilton has been in both "hard straight blows" and well-defined tornadoes, so that his words "judging from the way things were piled around, this must have been a regular funnel-shaped cloud" are entitled to some weight; but he also describes the whole as having been "a hard, straight blow, 6 to 10 miles wide and 50 miles long, lasting five or six hours, and at its worst (8:30 p. m. and 2 a. m.), with at least three funnel-shaped clouds," which he did not see and are not reported by others.

The winds experienced at Clayton, Kenton, etc., occurred in a very shallow trough of low pressure pitching northward and northeastward and gradually increasing in depth from the 5th of November to the morning of the 6th.—*C. A. jr.*

A LUMINOUS METEOR CLOUD OBSERVED AT URBANA, ILL.

By Prof. C. J. KULLMER. Dated Syracuse University, N. Y., December 14, 1908.

The growing recognition of the importance of meteor observations for the study of upper-air currents leads me to believe that some use may possibly be made of an observation made at Urbana, Ill., November 14, 1904. At $14^h 49^m 15^s \pm 4^s$ central time appeared in Leo Majoris a bright meteor, the course of which is given at No. 1 in fig. 1; the position was

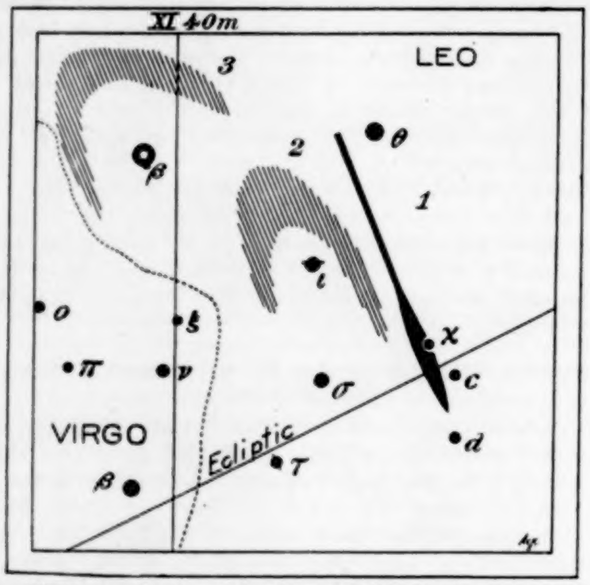

FIG. 1.—Meteor and meteor cloud in Leo Majoris, November 14, 1904.

accurately fixt by the small star triangle. In my note book I wrote: "At first two centers," which, interpreted from memory, means that at the beginning of the shaded part of the line a nucleus was formed; the meteor continuing, however, and forming a second nucleus. No. 2 in fig. 1 shows the position and shape of the luminous cloud while still visible to the naked eye; it remained thus visible for eight minutes, but my notes do not give the time of position No. 2. No. 3, however, shows the position and shape of the cloud at $15^h 4^m$ as seen thru an opera glass. This meteor was also observed at the university observatory, one mile to the west, by Dr. Joel Stebbins, who published a note concerning it in Popular Astronomy, vol. 13, p. 56. For the interpretation it may be convenient to add, that an area of high barometric pressure of 30.4 inches was central at longitude 86° west, latitude 36° north, about 300 miles southeast of Urbana, and a marked low pressure of 28.6 inches central at longitude 63° west, latitude 45° north. Other meteors observed at this time were: seven from $12^h 45^m$ to $13^h 45^m$; thirteen from $14^h 10^m$ to $15^h 15^m$; twenty-seven from $15^h 39^m$ to $16^h 39^m$.

THE TRAINING SCHOOL AT TOKYO, JAPAN, FOR METEOROLOGICAL OBSERVERS.

A letter dated November 23, 1908, from Prof. T. Okada, in charge of weather forecasting at the Central Meteorological Observatory, Tokyo, Japan, informs the Editor of the recent establishment and inauguration at that observatory of a training school for meteorological observers. This school is established for the members of the provincial meteorological stations, in order to provide such knowledge as is necessary for discharging their regular duties, and to secure more uniformity as well as a higher standard in their attainments. Apparently the course of instruction must cover several years of work. Observers who are graduates of a high school and have past entrance examinations at this observatory are admitted.

This year the number of students is 17. The courses of lectures are:

1. Mathematics. (Analytical geometry, differential calculus, and exercises.)
2. Physics. (Experimental physics.)
3. Apparatus and methods of observing.
4. Spherical astronomy (including spherical trigonometry.)
5. Seismology.
6. Meteorology (elementary and advanced.)
7. Physical experiments.
8. Meteorological observations.
9. Weather charts.

This extensive course of training at Tokyo covers even more ground than the analogous course established by Gen. William B. Hazen in 1882 for the benefit of the enlisted men under instruction at Fort Myer, Va., full details of which will be found in Annual Report Chief Signal Officer, 1882, Pt. I, p. 97–172. That course was maintained for several years under the special supervision of Prof. Frank Waldo.—*C. A.*

THE CLASS UNDER INSTRUCTION AT WASHINGTON.

A class for the instruction in station duties of newly appointed assistant observers has been established at the Central Office of the Weather Bureau at Washington, D. C. It is the intention, as far as practicable, to give each newly appointed assistant observer at least three months' training in the work done on station, including practise in telegraphy, typewriting, taking and enciphering of observations, preparation of forms, and the care of instruments. There are at present nine assistant observers under instructions.—*H. E. W.*

FORMATION OF DEW AT TREE-TOPS.

A correspondent inquires whether dew collects on the leaves at the tops of high trees so that they are moist at night in the summer time.

The general law with regard to the formation of dew simply requires that the surface on which dew forms shall be so cold that the air in contact with it and gently flowing over it, shall be cooled below its temperature of saturation, or to the temperature that we call the dew-point. This cooling can only be accomplished by radiation of heat from the surface outward thru the air, or by conduction from it inward thru the solid. The latter process is rare in nature, but is well illustrated in using the Regnault dew-point apparatus. The former process is the one ordinarily met with in nature. We think of the air near the ground as cooling slowly by its own radiation downward, since its radiation upward is counteracted, to a large extent, by absorbing the downward radiation from the air above it. Radiant heat has definite wave-lengths characteristic of its origin and these waves, radiating from a given body, are completely absorbed by other masses of the same body, but are not likely to be absorbed by masses of other bodies. When waves of radiation from the sun or the air strike a solid substance and penetrate its outer layer of molecules the latter radiate back heat of other and usually longer wave-lengths, and these pass thru the air with very slight absorption, except in so far as they are stopt by dust and fog or cloud. Thus it happens that the solid surfaces of the ground, vegetation, snow, or ice cool more rapidly than the air above them; the thin layer of air in immediate contact with the surfaces is especially cooled and leaves a little of its moisture on them as it settles down to some lower level by what has happily been called the drainage of cold air.

The rate of cooling by radiation increases in proportion as the surface is thermally insulated or cut off from receiving heat by conduction from the ground below; and also in proportion as it is more freely exposed to the clear blue sky above. Not only do clouds reflect back the heat radiated outward,

but the walls of buildings, the sides of valleys, and adjacent trees diminish the free exposure and the chance to radiate.

It would be difficult to say, a priori, just where to look for dew on the tops of high trees, but it occurs so frequently on the tops of high buildings that we are persuaded that it must sometimes occur on the tree tops. We hope that some of our correspondents may discover such locations and communicate directly with Mr. D. M. Rodgers, Special Field Agent, Bureau of Entomology, Department of Agriculture.—*C. A.*

HURRICANES AFFECTED BY MOUNTAIN RANGES.

In the Meteorological Bulletin of the Observatory Saint Martial, Port au Prince, Haiti, for the month of October, 1908, Prof. J. Scherer, director of the observatory, writing about the hurricanes of the 28th of September, says:

This cyclone was announced on the 25th by the Weather Bureau at Washington as then existing south of the island of St. Kitts and moving toward the WNW. It entered the island of Haiti at the Bay of Neybe [Neyda?] on the evening of the 27th. Traversing the northern slopes of the mountain ranges Santa de Bahoruco and La Selle, it past to the south of Fonds Parisien and of Ganthier, over Fonds Verretes, Pays Pourri Troucoucou and the upper courses of Grande Rivière du Cul de Sac, only to descend into the basin of the Momance and enter the ocean between Léogane and Port au Prince. Thence it continued its path toward the eastern point of Cuba, which it past over at 7 p. m.

The orography of the island has had a deflecting influence on the path of this hurricane. Without getting free from the high mountains of 2,000 meters it remained at an altitude of 1,000 meters thruout its principal path, leaving the crests of the high mountains on its left. After entering the island its first destruction was at Anse à Pitre, Grand Gosier, and Sale Trou, where there were 260 houses destroyed and 98 deaths. * * * On the right-hand side of the hurricane lies the Plaine du Cul de Sac, which suffered most. The principal rains fell after the passage of the hurricane; every river in the plain rose above its banks.

Here at Port au Prince the wind remained from the northeast up to 4 a. m.; at 5:10 a. m. it turned to the north where it remained only until 5:30 a. m., after which there was a calm of fifteen minutes. At 5:45 a. m. the wind suddenly jumped to the southeast and south-southeast.

The maximum velocity was 23 meters per second at 5:50 a. m.

The barometric readings were at 9 p. m., 756.9 mm.; at midnight, 756.2 mm.; 3 a. m., 753.1 mm.; 5 a. m., 746.0 mm.; 5:25 a. m., the minimum, 743.2 mm.; 6 a. m., 744.5 mm.; 7 a. m., 750.4 mm. During the calm the pressure rose 1.5 mm., but fell again until 5:55 a. m.

The minimum temperature occurred at the moment of the calm.

The relative humidity fell 10 per cent.

The direction of the motion of the clouds was, successively, NE., E., and S.

It is very desirable that some one should explain, in detail, the mechanism by which a given range of mountains or the coast of a continent deflects the path of a hurricane center. The east-west ranges in the West Indian Islands and the northeast-southwest Appalachian Range appear to have appreciable influences on some storms, but not on others.—*C. A.*

IS THE EARTH DRYING UP?

Under this startling heading the Literary Digest of July 11, 1908, discusses a memoir by G. Guilbert, published in the Bulletin of the Calvados Meteorological Commission.

We assume that our colleague does not intend to start a new sensational paragraph on its travels around the globe, but yet some of Mr. Guilbert's paragraphs have been so translated that, taken by themselves, the average reader would easily be led to infer that meteorologists are face to face with a climatological revolution. Thus a reviewer in Cosmos, under date of May 30, is said to have written:

The progressive diminution of rainfall is a fact that is becoming better and better established and even universally known. As meteorological observations are perfected and prolonged the phenomenon is more certain and forces itself upon our notice.

The writer then quotes the records of total annual rainfall and melted snow at Nancy, in the Department of Meurthe-et-Moselle, showing a diminution from 896 to 628 millimeters, or 28 per cent in thirty years, between 1878 and 1907, or at the rate of 1 per cent per annum, but he recognizes the fact that, of course, the rainfall can not go on constantly decreasing at this speed.

In nature everything vibrates, everything oscillates, the more the rainfall decreases the nearer will come the time when it will begin to increase.

Facts and logic alike concur in showing that a diminution of rainfall thus observed in one portion only of France has no counterpart elsewhere and is not universally known, and is not likely to be true everywhere.

But granting these alternations of wet and dry periods our colleague goes still further and adopts the theory that the diminution of rainfall—

* * * is a persistent and progressive phenomenon which nothing has checked since the origin of rain on the globe, at least since the glacial period, and which nothing will modify in the future—the rain will continue to diminish century by century as it has always done over the whole globe since prehistoric times.

From this wild statement an argument for the necessity of reforestation is then drawn: "If we do not wish to grow rapidly drier and drier * * * reforestation is necessary." One can but regret that such palpable errors, long since dropt by conservative students, should continue to be disseminated among the people.

Forests do not increase rainfall, but merely conserve it in the cool, sheltered, porous forest soil. Forests do not give back to the air and clouds more moisture than do cultivated fields or swamps or lakes or oceans; they are conservers, not lavish spenders; they do not themselves rob the air of moisture. The influence of reforestation, as such (to increase the rainfall or that of deforestation to diminish the rainfall), has been abundantly demonstrated to be quite inappreciable and probably nothing at all. To be sure forests grow on rocky slopes of mountains wherever there is sufficient soil and rainfall and heat, or a cloudy and moist atmosphere, but they also grow at sea-level on such plains as that of the Amazon, and wherever there is enough moisture, light, heat, etc.

The only way to prove that forests increase rainfall is to measure the precipitation before and after and during the process of reforestation *and be certain that your measurements are correct.* It is this last point that is most difficult of all. The slightest change in the exposure of a rain-gage to the wind *affects its catch, but not the rainfall,* and as for *correct* measurements of snowfall we are completely at sea.[1]

Local reforestation is advisable and necessary for many good reasons, but not in hopes of *increasing* the local rainfall. As for the so-called secular diminution of rainfall, we venture to assert that neither meteorology, nor geology, nor any other branch of geognosy gives clear, unimpeachable evidence of the progressive drying up of our globe as a whole. The fact that great glaciers, lakes, and rivers once covered regions now free from them merely shows that in those regions there was once a different relation than now exists between rainfall, snowfall, evaporation, and run-off, so that snow accumulated then more than now. At the present time there is more rain and less snow, or possibly more snow and more melting (possibly due to changes in altitude), so that the snow can not accumulate. The ratio of the snowfall in the cold half of the year to the rainfall in the warm half, must in general be large before snow will accumulate as in the glacial epochs of previous geological ages. Glacial phenomena tell us nothing whatever as to the absolute quantity of rain or snow.

As to the rainfall over the whole earth, all the statistics that have been accumulated in the past century have not sufficed to give us satisfactory information.

The works of Supan, 1898; Bartholomew, 1900; Herbertson, 1901; and Murray, 1903, serve only to give us very general ideas as to the *present* amount over the whole globe; as to the

[1] See "The measurement of precipitation," reprinted in the Monthly Weather Review for 1899, Vol. XXVII, p. 464-468.

secular change we know nothing at all. We can, however, perceive that the snowfall of winter results from water that was evaporated long before from tropical and equatorial regions, and that any excess of the glaciers of the Antarctic Continent over those of the Arctic must be due largely to the more abundant supply brought by moist ocean winds.

When the African Continent was 10,000 feet above ocean level with its great gorges of the Nile, the Congo, and the Zambesi, and when the submarine gorges off the mouths of the Congo and the Hudson were being eroded, both the African and the American continents *may* have had a larger snowfall and rainfall and a much larger outflow than now; but the existence of these gorges does not prove this since we see similar gorges now being cut down slowly by a comparatively small outflow in the Valley of the Colorado. Duration and quantity are equally important.

We think it is safe to say that no great changes in continents, oceans, or plateaus, arctic or antarctic, are likely to have made any correspondingly great change in the rainfall of the globe as a whole, and that therefore the globe is not now slowly drying up. The maximum annual rainfall that can occur on this globe as a whole is determined by the maximum total annual evaporation that can be caused by the sun's heat acting on the ocean, taken in connection with the maximum vertical interchange of air currents, since it is the cooling due to the latter that produces clouds and rain.—*C. A.*

TASMANIA AND THE TOTAL SOLAR ECLIPSE.

The meteorologist of Tasmania, W. H. C. Kingsmill, has called attention to the fact that the total solar eclipse of May 9, 1910, will be visible from that locality, and as this is one of the few places where observers can be located on land he anticipates that many government expeditions will be sent to that region. As these expeditions generally include not only technical astronomers but those representing other branches of science, such as meteorology, botany, and geology, it is likely that this event will be made the occasion of a very considerable addition to our knowledge of that region. American scientists are especially invited, and it is hoped that our meteorologists and botanists will improve the opportunity. An extensive scientific expedition analogous to that sent by the United States Government to the west coast of Africa in 1889 would be quite in order and probably yield as important results as those attained by the members of that expedition.—*C. A.*

DRIEST YEAR AT PORTLAND, ME.

By E. B. JONES, Local Forecaster. Dated Portland, Me., January 4, 1909.

In connection with the "Annual Index of Meteorological Notes," I will state that the year 1908 was the driest in the history of this station. Every month in the twelve was drier than normal, with three exceptions. The nearest approach to this record was in 1883, but this year had 1.25 inches of rain more than 1908.

During the year just ended there were only 30.74 inches of precipitation. The normal precipitation for the year in Portland is 42.51 inches, making a deficiency of 11.77 inches, or practically 1 foot.

June was the driest, for this month, on record and September was one of the driest, for the month, in the history of the local office. May was the only month which had any noticeable excess of precipitation.

As a result of the extreme dry weather, Maine suffered one of the greatest droughts in her history, forest fires destroyed hundreds of thousands of dollars worth of timber and other property, and crops were seriously injured and in many cases completely cut off.

At the present time the dry weather is being severely felt by mill owners and by farmers, who in many cases are hauling water from long distances. Many large industries have been obliged to shut down.

ADDRESS TO THE MATHEMATICAL AND PHYSICAL SECTION OF THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, DUBLIN, SEPTEMBER, 1908.

By W. N. SHAW, Sc.D., LL. D., F. R. S., President of the Section.[1]

It is with much misgiving that I endeavour to discharge the traditional duty of the president of a section of the British Association. So many other duties seem to find a natural resting place with anyone who has to reckon at the same time with the immediate requirements of the public, the claims of scientific opinion, and the interests of posterity, that, unless you are content with such contribution towards the advancement of the sciences of mathematics and physics as my daily experience enables me to offer you, I shall find the task impossible.

With a leaning towards periodicity perhaps slightly unorthodox I have looked back to see what they were doing in Section A fifty years ago. Richard Owen was President of the Association, William Whewell was President of Section A for the fifth time.

At the meeting of 1858 they must have spent some time over nineteen very substantial reports on researches in science, which included a large section of Mallett's facts and theory of earthquake phenomena, magnetic surveys of Great Britian and of Ireland, and, oddly enough, an account of the self-recording anemometer by Beckley; perhaps a longer time was required for fifty-seven papers contributed to the section, but very little was spent over the presidential address, for it only occupies two pages of print. My inclination towards periodicities and another consideration leads me to regard the precedent as a good one. That other consideration is that Section A has always more subjects for discussion than it can properly dispose of; and, in this case, discipline, like charity, might begin at home.

Since the section met last year it has lost its most illustrious member and its most faithful friend. Lord Kelvin made his first contribution to Section A at Cambridge in 1845, on the elementary laws of statical electricity; he was president of the section in 1852 at Belfast for the first of five times. I have looked to see what suggestion I could derive from his first essay in that capacity. I can find no reference to any address in the published volume. I wish I had the courage to follow that great example.

Lord Kelvin's association with Section A was so constant and so intimate that it requires more than a passing word of reference. There is probably no student of mathematics or physics grown into a position of responsibility in this country but keeps among his treasured reminiscences some words of inspiration and of encouragement from Kelvin, spoken in the surroundings which we are once more met to inaugurate. I

[1] On the occasion of the recent meeting of the British Association at Dublin the Senate of Dublin University conferred honorary degrees on many distinguished men including the following well-known meteorologists:

Dr. W. N. Shaw, Director of the Meteorological Office, London; Capt. H. G. Lyons, Director-General of the Survey Department in Egypt.

Also the following, who have contributed more or less directly to our science:

Sir David Gill, late Director of the Royal Observatory, Cape Town, South Africa; Dr. Horace Lamb, Professor of Mathematics, University of Manchester, England; Dr. E. Rutherford, Professor of Physics, University of Manchester, England, formerly of McGill University, Montreal, Canada.

The elegant address of Dr. W. N. Shaw, as President of the Mathematical and Physical Section (Section A) of the British Association, will, we believe, be instructive to every reader of the Monthly Weather Review, and we therefore reprint it in full.

refer to those unrecorded acts of kindness and help because they were really a striking characteristic of Section A. Their value for the amenity as well as for the advancement of science it would be difficult to overestimate. I could not, even if time permitted, hope to set before you an adequate appreciation of Kelvin's contributions to science as illustrated by his communications to this section, and in this place it is not necessary. But I can not pass over that feature of his character without notice.

Closely following on the loss of Kelvin came the death of Sir Richard Strachey, a personal loss to which it is difficult to give expression. I am not aware that he had much to do with Section A. I wish, indeed, that the section had seen its way to bring him more closely into touch with its proceedings. He was president of Section E in 1875, and, by appointment of the Royal Society, he was for twenty-two years chairman of the Meteorological Council. I had the good fortune to be very closely associated with him during the last ten years of his life, and to realise the ideas which lay behind his official actions and to appreciate the reality of his services to science in the past and for the future.

These losses unfortunately do not stand alone. Only last year Sir John Eliot received the congratulations of all his fellow workers upon the publication of his Climatological Atlas of India as representing the most conspicuous achievement of orderly, deliberate, purposeful compilation of meteorological facts for a special area that has yet been seen. He was full of projects for a handbook to accompany the atlas, and of ideas for the prosecution of meteorological research over wide areas by collecting information from all the world and enlisting the active cooperation of the constituent parts of the British Empire in using those observations for the advancement of science and the benefit of mankind. He died quite suddenly on March 18, not young as years go, but quite youthful in the deliberate purpose of manifold scientific activities and in his irrepressible faith in the future of the science which he has adorned.

The section will, I hope, forgive me if I put before them some considerations which the careers of these three men suggest. Kelvin, a mathematician, a natural philosopher, a university professor, some part of whose scientific work is known to each one of us. He was possessed with the notion that mathematics and natural philosophy are applicable in every part of the work of daily life, and made good the contention by presenting to the world, besides innumerable theoretical papers, instruments of all degrees of complexity, from the harmonic analyser to an improved water-tap. It was he who transfigured and transformed the mariner's compass and the lead-line into instruments which have been of the greatest practical service. It was he who, when experimental science was merely a collection of facts or generalisations, conceived the idea of transfiguring every branch of it by the application of the principles of natural philosophy, as Newton had transfigured astronomy. The ambition of Thomson and Tait's Natural Philosophy, of which only the first volume reached the stage of publication, is a fair index of Kelvin's genius.

Strachey, on the other hand, by profession a military engineer, a great administrator, head of the Public Works Department in India, deeply versed in finance and in all the other constituent parts of administration, by his own natural instinct demanded the assistance of science for every branch of administration. In promoting the development of botany, of meteorology, of geodesy, and of mathematics, he was not administering the patronage of a Macænas, but claiming the practical service of science in forestry, in agriculture, in famine relief, in public works, and in finance. You can not gauge Strachey's services in science by the papers which he contributed to scientific societies, if you leave out of account the fact that they were really incidents in the opening of fresh channels of communication between scientific work and the public service.

And Eliot, as Meteorological Reporter to the Government of India, an accomplished mathematician (for he was second wrangler and first Smith's prizeman in 1869), a capable and devoted public servant, the medium by which Strachey's ideas as regards the use of meteorology in administration found expression in the Government of India, who caught the true perception of the place of science in the service of the State, and made his office the indispensable handmaid of the Indian administration. These three men together, who have all passed away within a space of three months, are such representative types of scientific workers, complementary and supplementary that a similar combination is not likely to occur again. All three indispensable, yet no two alike, except in their enthusiasm for the sciences for the advancement of which Section A exists.

To these I might indeed add another type, the private contributor to the physical exploration of the visible universe, of which Ireland furnishes so many noble examples; and in that connection let me give expression to the sense of grievous loss, to this association and science, occasioned by the premature death of W. E. Wilson, of Daramona, a splendid example of that type.

In the division of the work of advancing the sciences of mathematics and physics and their application to the service of mankind, I am reminded of Dryden's somewhat lopsided comparison of the relative influence of music and song in his Ode to St. Cecelia's Day. If I may be pardoned for comparing small things with great, the power of Timotheus' music over Alexander's moods was hardly less complete than Kelvin's power to touch every department of the working world with his genius. But I may remind you that, after a prolonged description of the tremendous influence of Timotheus upon the victorious hero, the poet deals in one stanza with his nominal subject:—

> At last divine Cecilia came,
> Inventress of the vocal frame;
> The sweet enthusiast, from her sacred store,
> Enlarged the former narrow bounds
> * * * * * *
> With nature's mother-wit, and arts unknown before.
>
> Let old Timotheus yield the prize,
> Or both divide the crown;
> He raised a mortal to the skies,
> She drew an angel down.

I doubt if any of my hearers who knew Strachey by sight would recognise in him the scientific reincarnation of St. Cecilia, but it is none the less true that he was preeminent among men in inventing the means of drawing angels down and using their service for the attuning of common life to a scientific standard. It may be equally hard for those who knew him to look upon Eliot as a vocal frame, for of all his physical capacities his voice was the least impressive; and yet it is not untrue to say that he was conspicuously a medium by which the celestial harmonies of the physical sciences were brought into touch with the practical life of India through his work, which is represented by a considerable number of the twenty volumes of Memoirs of the Indian Meteorological Service.

I do not indulge in this poetic extravagance without some underlying reason. Speaking for the physics of the atmosphere, there is a real distinction between these three sides of scientific work. To some is given the power of the mathematician or the physicist to raise the mortal to the skies, to solve some problem which, if not in itself a meteorological one, still has a bearing, sooner or later to be discovered and developed, upon the working of atmospheric phenomena. It is easy enough to cite illustrious examples: among notable instances there recur to my mind Rayleigh's work on the colour of the

sky and Pernter's meteorological optics; papers by Ferrel and others on the general circulation of the atmosphere; the papers by Hagen, Helmholtz, Oberbeck, Margules, Hertz, and Von Bezold on the dynamics and thermodynamics of the atmosphere, collected and translated by Cleveland Abbe; the work on atmospheric absorption by Langley and the theoretical papers on radiation by Poynting; those on condensation nuclei by Aitken and Wilson, and the recent work on atmospheric electricity, including the remarkable paper by Wilson on the transference of electricity from the air to the ground.

But these things are not of themselves applied to the meteorology of every-day life. It is, in a way, a separate sense, given to few, to realize the possibilities that may result from the solution of new theoretical problems, from the invention of new methods—to grasp, in fact, the idea of bringing the angels down. And, in order that the regular workers in such matters may be in a position constantly to reap the advantages which men of genius provide, the vocal frame must have its permanent embodiment. For the advancement of science in this sense we require all three—the professor with academic freedom to illuminate with his genius any phenomenon which he may be pleased to investigate, the administrator, face to face with the practical problems in which science can help, and the living voice which can tune itself in harmony with the advances of science and in sympathy with the needs of the people whom it serves.

The true relations of these matters are not always apparent. Eliot, bringing to the work of the Indian Meteorological Office a mind trained in the mathematical school of which Kelvin was a most conspicuous exponent, achieved a remarkable success, with which perhaps my hearers are not familiar.

In this country there is a widespread idea that meteorology achieves its object if by its means the daily papers can give such trustworthy advice as will enable a cautious man to decide whether to take out his walking-stick or his umbrella. Some of us are accustomed to look upon India as a place of unusual scientific enlightenment, where governments have a worthy appreciation of the claims of science for recognition and support. But Eliot was never tired of telling me that it was the administration of India, and not the advancement of science, that the Indian administrators had in view; and among his achievements the one of which he was the most proud was that the conduct of his office upon scientific lines during his tenure had so commended itself to the administrators that his successor was to be allowed three assistants, with special scientific training, in order that the State might have the benefit of their knowledge.

It is, of course, easy to suggest in explanation of this success that the Department of Public Works of India can not afford to be unmindful of the distribution of rainfall, and that there is an obvious connection between Indian finances and Indian droughts; but it is a new fact in British history that the application of scientific considerations to the phenomena of rainfall are of such direct practical importance that meteorological information is a matter of consequence to all Government officials, and that meteorological prospects are a factor of finance. Imagine his Majesty's Chancellor of the Exchequer calling at 63 Victoria street to make inquiries with a view to framing his next Budget, or taking his prospects of a realized surplus from the Daily Weather Report. Yet in India meteorology is to such an extent a public servant that such proceedings would not excite remark.

To have placed a scientific service on such a footing is, indeed, a notable success. Again, I rely on Eliot when I say that that success is only to be achieved by being constantly on the watch to render service wherever service can be rendered. There is a difference between this attitude and that which has for its object the contribution of an effective paper to a scientific publication; in other words, it must be frankly recognised that the business of the scientific departments of Government is not to raise an occasional mortal to the skies, but to draw down as many angels as are within reach. I was much surprised, when Eliot wished to develop a large scheme for meteorological work on a wider scale, that he made his appeal to the British Association as Chairman of the Sub-section for Cosmical Physics at Cambridge, and thereby to the Governments of this country and the colonies. He felt that he could only urge the Indian Government to join, and he did so successfully, so far as India would be directly benefited thereby, however important the results might be from a purely scientific point of view. Strange as it may appear to some, it was to this country that he looked for assistance, on the plea of the increase of knoweledge for its own sake, or for the sake of mankind at large.

I am disposed, therefore, to carry your thoughts a little further, and rely on your patience while I consider another aspect for the process of drawing down the angels from the mathematical and physical sky, a process which is sufficiently indicative of the functions of a state scientific department. Viewing the world at large, and not merely that part of it with which we are ourselves immediately concerned, such departments deal with celestial physics in astronomy, with the physics of the air in meteorology, and atmospheric electricity, with the physics of land and water in physical geography and geology, seismology and terrestrial magnatism, oceanography and hydrography. It is for the practical applications of these sciences to the service of the navigator, the fisherman, the husbandman, the miner, the medical man, the engineer, and the general public that there is an obvious public want.

Let me carry you with me in regarding these departments, primarily, as centers for establishing the growth of science by bringing it to bear upon the practical business of life, by a process of regular plantation, and not the occasional importation of an exotic scientific expert. I shall carry you with me also if I say that the gravest danger to such scientific institutions is the tendency to waste. I use the term "waste," not in its narrowest, but in its most liberal sense, to include waste of money, waste of effort, waste of scientific opportunity. I do not regard it as a waste that such a department should be unable to emulate Timotheus' efforts. Any aspiration in that direction is, of course, worthy of every encouragement, but the environment is not generally suitable for such achievements. I do, however, regard it as waste if the divine Cecilia is not properly honored, and if advantage is not taken of the fullest and freest use of the newest and best scientific methods, and their application in the widest manner possible.

I speak for the office with which I am connected when I say its temptations to waste are very numerous and very serious. It is wasteful to collect observations which will never be used; it is equally wasteful to decline to collect observations which in the future may prove to be of vital importance. It is wasteful to discuss observations that are made with inadequate appliances; it is equally wasteful to allow observations to accumulate in useless heaps because you are not sure that the instruments are good enough. It is wasteful to use antiquated methods of computation or discussion; it is equally wasteful to use all the time in making trial of new methods. It is wasteful to make use of researches if they are inaccurate; it is equally wasteful to neglect the results of researches because you have not made up your mind whether they are accurate or not. It is wasteful to work with an inadequate system in such matters as synoptic meteorology; it is equally wasteful to lose heart because you can not get all the facilities which you feel the occasion demands.

It is the business of those responsible for the administration of such an office to keep a nice balance of adjustment between the different sides of activity, so that in the long run the waste is reduced to a minimum. There must in any case be a good

deal of routine work which is drudgery; and if one is to look at all beyond the public requirements and public appreciation of the immediate present, there must be a certain amount of enterprise and consequently a certain amount of speculation.

Let me remark by the way that there is a tendency among some of my meteorological friends to consider that a meteorological establishment can be regarded as alive, and even in good health, if it keeps up its regular output of observations in proper order and up to date, and that initiative in discussing the observations is exclusively the duty of a central office. That is a view that I should like to see changed. I do not wish to sacrifice my own privilege of initiative in meteorological speculation, but I have no wish for a monopoly. To me, I confess, the speculation which may be dignified by the name of meteorological research is the part of the office work which makes the drudgery of routine work tolerable. For my part I should like every worker in the office, no matter how humble his position may be, somehow or other to have the opportunity of realizing that he is taking part in the unraveling of the mysteries of the weather; and I do not think that any establishment, or section of an establishment, that depends upon science can be regarded as really alive unless it feels itself in active touch with that speculation which results in the advancement of knowledge. I do not hesitate to apply to other meteorological establishments, and indeed to all scientific institutions that claim an interest in meteorology, the same criterion of life that I apply to my own office. It is contained in the answer to the question, How do you show your interest in the advancement of our knowledge of the atmosphere? The reply that such and such volumes of data and mean values measure the contribution to the stock of knowledge leaves me rather cold and unimpressed.

But to return to the endeavor after the delicate adjustment between speculation and routine, which will reduce the waste of such an institution to a minimum; experience very soon teaches certain rules.

I have said elsewhere that the peculiarity of meteorological work is that an investigator is always dependent upon other people's observations; his own are only applicable in so far as they are compared with those of others. Up to the present time, I have never known anyone to take up an investigation that involved a reference to accumulated data, without his being hampered and harassed by uncertainties that might have been resolved if they had been taken in time. I shall give you an example presently, but, in the meantime, experience of that kind is so universal that it has now become with us a primary rule that any data collected shall be forthwith critically examined and so far dealt with as to make sure that they are available for scientific purposes—that is, for the purposes of comparison. A second rule is that as public evidence of the completion of this most important task there shall be at least a line of summary in a published report, or a point on a published map, as a primary representation of the results. Such publication is not to be regarded as the ultimate application of the observations, but it is evidence that the observations are there, and are ready for use.

You will find, if you inquire, that at the Office we have been gradually lining up these troops of meteorological data into due order, with all their buttons on, until, from the commencement of this year, anyone who wishes to do so can hold a general review of the whole meteorological army, in printed order—first order stations, second order stations, rainfall stations, sunshine and wind stations, sea temperatures and other marine observations—on his own study table, within six months of the date of the observations, upon paying to His Majesty's Stationery Office the modest sum of four shillings and sixpence. For all the publications except one the interval between observation and publication is only six weeks, and as that one has overtaken four years of arrears within the last four years, I trust that by the end of this year six weeks will be the full measure of the interval between observation and publication in all departments. This satisfactory state of affairs you owe to the indefatigable care and skill of Captain Hepworth, Mr. Lempfert, and Mr. R. H. Curtis, and the members of the staff of the Office who work under their superintendence. I need say little about corresponding work in connection with the Daily Weather Report, in which Mr. Brodie is my chief assistant, although it has received and is receiving a great deal of attention. The promptitude with which the daily work is dealt with hardly needs remark from me, though I know the difficulties of it as well as anyone. If I spend only one long sentence in mentioning that on July 1, 1908, the morning hour of observation at twenty-seven out of the full number of twenty-nine stations in the British Isles was changed from 8 a. m. to 7 a. m., and the corresponding post-offices, as well as the Meteorological Office, opened at 7:15 a. m. in order to deal with them, so that we may have a strictly synchronous international system for western and central Europe, and thus realise the aspiration of many years, you will not misunderstand me to mean that I estimate the task as an easy one.

The third general rule is that the effectiveness of the data of all kinds, thus collected and ordered, should be tested by the prosecution of some inquiry which makes use of them in summary or in detail. It is here that the stimulating force of speculative inquiry comes in; and it is in the selection and prosecution of these inquiries, which test not only the adequacy and effectiveness of the data collected, but also the efficiency of the Office as contributing to the advance of knowledge, that the most serious responsibility falls upon the administrators of Parliamentary funds.

Scientific Shylocks are not the least exacting of the tribe, and there have been times when I have thought I caught the rumination:

> *Shy.* Three thousand ducats? 'tis a good round sum!
> *Bas.* For the which, as I told you, Antonio shall be bound.
> * * * * * * *
> *Shy.* Antonio is a good man?
> *Bas.* Have you heard any imputation to the contrary?
> *Shy.* Oh! no, no, no, no. * * * Yet his means are in supposition: he hath an argosy bound to Tripolis, another to the Indies; I understand, moreover, upon the Rialto, that he hath a third in Mexico, a fourth for England, and other ventures he hath squandered abroad. But ships are but boards, sailors but men. There is the peril of water, winds, and rocks. * * * Three thousand ducats.

We at the Meteorological Office are very much in Antonio's position. Our means of research are very much in supposition: four observatories and over four hundred stations of one sort or another in the British Isles; an elaborate installation of wind-measuring apparatus at Holyhead; besides other ventures squandered abroad; an anemometer at Gibraltar, another at St. Helena; a sunshine recorder at the Falkland Isles, half a dozen sets of instruments in British New Guinea, and a couple of hundred on the wide sea. The efforts seem so disconnected that the rumination about the ducats is not unnatural.

And you must remember that we lack an inestimable advantage that belongs to a physical laboratory or a school of mathematics, where the question of the equivalent number of ducats does not arise in quite the same way. The relative disadvantage that I speak of is that in an office the allowance for the use of time and material in practice and training disappears. All the world seems to agree that time or money spent on teaching or learning is well spent. In the course of twenty years' experience at a physical laboratory, and in examinations not a few, I have seen **M** and **H** or the wavelength of sodium light determined in ways that would earn very few ducats on the principle of payment by results; but, having regard to the psychological effect upon the culprit or the examiner, the question of ducats never came in. Wisely

or unwisely public opinion has been educated to regard the psychological effect as of infinite value compared with the immediate result obtained. But in an office the marks that an observer or computer gets for showing that he 'knew how to do it,' when he did not succeed in doing it, do not count towards a 'first class,' and we have to abide by what we do; we can not rely on what we might have done. Consequently our means in supposition, spread over sea and land, are matters of real solicitude. In such circumstances there might be reason for despondency if one were dependent merely upon one's own ventures and the results achieved thereby. But when one has the advantage of the gradual development of investigations of long standing, it is possible to maintain a show of cheerfulness. When Shylock demands his pound of flesh in the form of an annual report, it is not uncommon at all to find that some argosy that started on its voyage long ago 'hath richly come to harbour suddenly.' There have been quite a number of such happy arrivals within the last few years.

I will refer quite briefly to the interesting relations between the yield of barley and cool summers, or the yield of wheat and dry autumns, and the antecedent yield of eleven years before, which fell out of the body of statistics collected in the Weekly Weather Report since 1878. The accomplished statisticians of the Board of Agriculture have made this work the starting point for a general investigation of the relation between the weather and the crops, which can not fail to have important practical bearings.

Let me take another example. For more than a full generation meteorological work has been hampered by the want of a definite understanding as to the real meaning in velocity, or force, of the various points of the scale of wind estimates laid down in 1805 by Admiral Beaufort for use at sea, and still handed on as an oral tradition. The prolonged inquiry, which goes back really to the report on the Beckley anemograph already referred to, issued quite unexpectedly in the simple result that the curve

$$p = 0.0105B^3$$

(where p is the force in pounds per square foot, and B the arbitrary Beaufort number) runs practically through nine out of the eleven points on a diagram representing the empirical results of a very elaborate investigation. The empirical determinations upon which it is based are certainly not of the highest order of accuracy; they rely upon two separate investigations besides the statistical comparison, viz, the constant of an anemometer and the relation of wind-velocity to wind-pressure, but no subsequent adjustment of these determinations is at all likely to be outside the limits of an error of an estimate of wind-force; and the equation can be used, quite reasonably, as a substitute for the original specification of the Beaufort scale, a specification that has vanished with the passing of ships of the type by which it was defined. This result, combined with the equation $p = 0.003V^2$, which has been used in the Office for many years, and has recently been confirmed as sufficiently accurate for all practical purposes by Dr. Stanton at the National Physical Laboratory and Monsieur Eiffel at the Eiffel Tower, places us upon a new plane with regard to the whole subject of wind measurement and wind estimation.

Results equally remarkable appear in other lines of investigation. Let me take the relation of observed wind velocity to barometric gradient. You may be aware that in actual experience the observed direction of the wind is more or less along the isobars, with the low pressure on the left of the moving air in the Northern Hemisphere; and that crowded isobars mean strong winds. Investigations upon this matter go back to the earliest days of the Office.

There can be no doubt that the relation, vague as it sometimes appears to be upon a weather chart, is attributable to the effect of the earth's rotation. In order to bring the observed wind velocity into numerical relation with the pressure gradient, Guldberg and Mohn assumed a coefficient of surface 'friction,' interfering with the steady motion. The introduction of this new quantity, not otherwise determinable, left us in doubt as to how far the relation between wind and pressure distribution, deducible from the assumption of steady motion, could be regarded as a really effective hypothesis for meteorological purposes.

Recent investigations in the Office of the kinematics of the air in travelling storms, carried out with Mr. Lempfert's assistance, have shown that, so far as one can speak of the velocity of wind at all—that is to say, disregarding the transient variations of velocity of short period and dealing with the average hourly velocity, the velocity of the wind in all ordinary circumstances is effectively steady in regard to the accelerating forces to which it is subject. This view is supported by two conclusions which Mr. Gold has formulated in the course of considering the observations of wind velocity in the upper air, obtained in recent investigations with kites. The first conclusion is that the actual velocity of wind in the upper air agrees with the velocity calculated from the pressure distribution to a degree of accuracy which is remarkable, considering the uncertainties of both measurements; and the second conclusion affords a simple, and I believe practically new, explanation upon a dynamical basis of the marked difference between the observed winds in the central portions of cyclones and anticyclones, respectively, by showing that, on the hypothesis of steady motion, the difference of sign of the effective acceleration, due to curvature of path and to the earth's rotation respectively, leads to quite a small velocity and small gradient as the limiting values of those quantities near anticyclonic centers.

This conclusion is so obviously borne out by the facts that we are now practically in a position to go forward with the considerable simplification which results from regarding the steady state of motion in which pressure gradient is balanced by the effective acceleration due to the rotation of the earth and the curvature of the path, as the normal or ordinary state of the atmosphere.

I can not forbear to add one more instance of an argosy which has richly come to harbour so lately as this summer. You may be aware that Kelvin was of the opinion that the method of harmonic analysis was likely to prove a very powerful engine for dealing with the complexities of meteorological phenomena, as it has, in fact, dealt with those of tides. In this view Sir Richard Strachey and the Meteorological Council concurred, and an harmonic analyser was installed in the Office in 1879, but subsequently numerical calculation was used instead. A considerable amount of labour has been spent over the computation of Fourier coefficients. Not many great generalisations have flowed from this method up to the present time. I have no doubt that there is much to be done in the way of classifying temperature conditions, for climatic purposes, by the analysis of the seasonal variations. A beginning was made in a paper which was brought to the notice of the Association at Glasgow. The most striking result of the Fourier analysis we owe to Hann, who has shown that, if we confine our attention to the second Fourier coefficient of the diurnal variation of pressure—that is, to the component of twelve-hour period—we get a variation very marked in intertropical regions, and gradually diminishing poleward in both hemispheres, but synchronous in phase throughout the 360 degrees of a meridian. The maximum occurs along all meridians in turn about 10 a. m. and 10 p. m. local time. This semidiurnal variation with its regular recurrence is well known to mariners, and we have recently detected it, true to its proper phase, in the observations at the winter quarters of the *Discovery*; small in amplitude indeed—about a

thousandth of an inch of mercury—but certainly indentifiable.

The reality of this variation of pressure, common to the whole earth, can not be doubted, and so far as it goes, we may represent it (if indeed we may represent pressure differences as differences in vertical heights of atmosphere) as the deformation of a spherical atmosphere into an elipsoid, with its longest axis in the equator pointing permanently 30° to the west of the sun. Its shortest axis would also be in the equator, and its middle axis would be along the polar axis of the earth. Somehow or other this protuberance remains fixed in direction with regard to the sun, while the solid earth revolves beneath it. Whatever may be the cause of this effect, obviously cosmical, and attributable to the sun, at which it indirectly points, its existence has long been recognised, and further investigation only confirms the generalisation. It is now accepted as one of the fundamental general facts of meteorology.

Professor Schuster, for whose absence from this meeting I may venture to express a regret which will be unanimous, has already contributed a paper to the Royal Society pointing out the possible relations between the diurnal variations of pressure and those of terrestial magnetic force. Going back again to the ubiquity of the application of the relation of pressure and wind, in accordance with the dynamical explanation of Buys Ballot's law, we should expect the effect of a pressure variation that has its counterpart in that of terrestrial magnetism to be traceable also in wind observations.

Mr. J. S. Dines has just given me particulars of the discovery of that effect in the great air current, the variations of which I have called the pulse of the atmospheric circulation—I mean the southeast trade wind, the most persistent atmospheric current in the world. It is difficult as a rule to get observers to pay much attention to that current, because it is so steady; but in 1891 the Meteorological Council set up an anemometer at St. Helena, in the very heart of the current, and we have just got out the results of the hourly tabulations. When the observations for the hours 1 to 24 are grouped separately for months, so as to give the vector resultants for each hour and for each month, it appears that there is a conspicuous semidiurnal variation in the current, which shows itself as a closed polygon of vector variations from the mean of the day.

The month of April gives the most striking diagram of the twelve. It displays the superposition of two practically complete dodekagons, one a large one, completing its cycle from 6 a. m. to 6 p. m., the other a small one, for 6 p. m. to 6 a. m. The resultant wind for the whole day is very nearly southeast, and practically remains so for all the months of the year, the monthly variation of resultant wind being confined to a change of velocity from about 14 miles per hour in May to about 21 miles per hour in September.

If, instead of combining the south and east components to form a vector diagram, we plot their variations separately, the semidiurnal in each is plainly marked; and the calculation of its constants shows that its amplitude is about three-quarters of a mile per hour both in the south and rather less in the east component. The easterly increment has its maxima at 10 a. m and 10 p. m., and at these hours the phase of the variation of the southerly component is nearly opposite. Thus, to correspond with the semidiurnal variation of pressure, there is a semidiurnal variation in the trade wind at St. Helena, which is equivalent to the superposition upon the resultant wind of a northeasterly component of about 1 mile per hour amplitude, with maxima at 10 a. m. and 10 p. m., the hours when the ellipsoidal deformation of the spherical atmosphere is passing over the locality.

I have only dealt with one month. I believe that when all the results that flow from this simple statement can be put before you, you will agree with me that the argosy which the Meteorological Council sent out in 1891 has indeed richly come to harbour.

Let me digress to say a word in illustration of the principle I laid down that, if one would avoid waste in meteorological work, the observations must be examined forthwith and so far discussed that any ambiguities may be cleared up.

After some years of wear at St. Helena the persistent rubbing of the southeast part of the spiral metallic pencil upon the metallic paper wore away the metal and left a flat place. This got so bad that the instrument had to come home for repairs, and when it was set up again, after a year's absence, the average direction of the trade wind differed by two points from the average of most, but not of all, of the previous years. So far as we know, the orientation has been attended to, as before, and yet it is hardly possible to resist the suggestion that the anemometer has been set slightly differently. We are now making very careful inquiries from the observer; but, in the meantime, it seems to me that there is a great opportunity for a competent mathematical physicist to help us. Dynamical explanations of the trade winds have been given from the time of Halley. Let me offer as a simple question in the mathematical physics of the atmosphere whether a variation of two points in the direction of the southeast trade wind between the years 1903 and 1905 can be regarded as real, and, if not, which of the two recorded directions is the correct one?

It would be appropriate for me to add some words about the results of last year's work upon the upper air, in which we had the valuable cooperation of the University of Manchester. These results have disclosed a number of points of unusual interest. But we are to have an opportunity of considering that subject in a discussion before the section, and I need not deal with it here. I must, however, pause to give expression of the thanks of all meteorologists to Professor Schuster for his support of the Manchester University station at Glossop Moor. I may remind you that this generous contribution for the advancement of science on the part of Professor Schuster is in addition to the foundation of a readership in mathematical physics at Manchester and a readership in dynamical meteorology, now held by Mr. Gold at Cambridge.

I have said enough to show that the speculative ventures of official meteorologists are not all failures, and I will only add that if any mathematician or physicist would like to take his luck on a meteorological argosy he will be heartily welcomed. Part of the work will be drudgery; he must be prepared to face that; but the prospects of reaching port are reasonably good, so much so, indeed, that such a voyage might fairly lead to a claim for one of the higher academical degrees.

Up to now I have been dealing with the adjustment of official scientific work to reduce waste to a minimum, in so far as it lies within the control of those responsible for an office. I turn now to an aspect of the matter in which we require the assistance of others, particularly of the British Association.

The most serious danger of waste in a busy office is that it should carry on its work without an adequate knowledge of what is being done in advancing science and improving methods elsewhere. I speak myself for the Meteorological Office alone, but I believe that the responsible officials of any scientific government department will agree with what I say.

Year by year some Timotheus "with his sounding flute and tuneful lyre" performs some miracle by the application of reasoning to the phenomena of nature. Only last year you heard Professor Love in his presidential address treat of the mundane question of the shape of the earth and etherealize the grim actualities with the magic of his spherical harmonics. Year by year, in every one of the subjects in which the practical world is immediately interested, active students, whether public officials, academic officials, or private enthusiasts, not only keep alight the sacred flame but occasionally add to its

brilliance; and all the new knowledge, from whencesoever it comes, ought to be applied to the service of the State.

The actual volume of original contributions on these subjects is by no means inconsiderable. You are all aware that, some years ago, the Royal Society initiated a great international enterprise for the compilation of a catalogue of scientific literature. I have been looking at the fifth annual issue of the volume on Meteorology, including Terrestrial Magnetism. I may remark that the catalogue is quite incomprehensibly eclectic as regards official literature, but let that pass. I find that, in the year that closed with July, 1907, 1,042 authors (not counting offices and institutions as such) presented to the world 2,131 papers on Meteorology, 229 on Atmospheric Electricity, and 180 on Terrestrial Magnetism. This will give some idea of the annual growth in these subjects, and may convince you that after all allowance is made for duplicate titles, for papers of no importance, and for mere sheets of figures published for purposes of reference, there remains a bulk of literature too large for any single individual to cope with if he has anything else to do.

If instead of confining ourselves to what can be included in meteorology alone we extend our view over the other allied sciences, it would be necessary to take in other volumes of the International Catalogue, and there would be some overlapping. I have taken instead the volume of the Fortschritte der Physik for 1906, which deals with Kosmische Physik. It is edited by Professor Assmann, who adds to his distinction as head of the Royal Prussian Aeronautical Observatory of Lindenberg that of an accomplished bibliographer. In this volume are given abstracts or titles of the papers published during the year which can be regarded as worthy of the attention of a physicist. An examination of the volume gives the following numbers of the papers in the different sections:

		Papers.
Astro-Physics		222
Meteorology		1,122
Atmospheric Electricity		135
Geophysics:		
Geodetics	105	
Seismology and Volcanic Phenomena	256	
Terrestrial Magnetism and Aurora	108	
Currents, Tides, and Waves	46	
Inland Hydrography	117	
Ice, Glaciers, and Ice Age	139	
Other papers	126	
		897
Total		2,376

I need hardly say that these 2,376 papers are not all English; in some of the sections few of them are in that language and fewer still are British. If British students, official and unofficial, are to make the most of the operation of drawing the angels down, they need help and cooperation in dealing with this mass of literature, in winnowing the important from the unimportant, and in assimilating that which makes for the real progress of the practical application of science. This is the more necessary for these subjects because there is no organized system of academic teaching, with its attendant system of text-books. In a subject which has many university teachers it might reasonably be supposed that any important contribution would find its way into the text-books, which are constantly revised for the use of students; and yet in his presidential address to the Royal Society in the November of last year, Lord Rayleigh felt constrained to point out that, for the advance of science, although the main requirement is original work of a high standard, that alone is not sufficient. "The advances made must be secured, and this can hardly be unless they are appreciated by the scientific public." He adds that "the history of science shows that important original work is liable to be overlooked and is, perhaps, the more liable the higher the degree of originality. The names of T. Young, Mayer, Carnot, Waterston, and B. Stewart, will suggest themselves to the physicist, and in other branches, doubtless, similar lists might be made of workers whose labours remained neglected for a shorter or longer time."

If this is true of physics, how deplorably true it is of meteorology. If I allow a liberal discount of over 50 per cent from the numbers that I have given, and estimate the number of effective contributions to meteorology as recognized by the International Catalogue at a thousand, which agrees pretty well with that given by the Fortschritte der Physik, and if I were to ask round this room the number of these papers read by anyone here present, I am afraid the result would be disheartening. Many of us have views as to the way in which the study of meteorology ought to be pursued, but the views are not always based on an exhaustive examination of the writings of meteorologists. Few of us could give, I think, any reasonable idea of the way in which it is being pursued by the various institutions devoted to its application, and of the progress which is being secured therein. Meteorological papers are written by the hundred, and whether they are important or unimportant they often disregard what has been already written in the same or some other language, and are themselves in turn disregarded. I do not think I should be doing any injustice if I applied similar remarks to some of the other subjects included in the table which I have quoted. How many readers are there in this country for an author in terrestrial magnetism, atmospheric electricity, limnology, or physical oceanography? But if the papers are not read and assimilated, the advancement of science is not achieved, however original the researches may be.

By way of remedy for the neglect of important papers in physics, Lord Rayleigh suggests that teachers of authority, who, from advancing years or from some other reason, find themselves unable to do much more work in the direction of original contributions, should make a point of helping to spread the knowledge of the work done by others. But what of those subjects in which there are no recognized teachers? and in this country this is practically the case with the subjects which I have mentioned. It is true that many of them are made the occasion of international assemblies, at which delegates or representatives meet. But such international assemblies are of necessity devoted, for the most part, to the elaboration of the details of international organisation, and not to the discussion of scientific achievements. The numbers attending are, equally of necessity, very restricted.

The want of opportunity for the discussion of progress in these sciences is specially lamentable, because in its absence they lose the valuable assistance of amateur workers, who might be an effective substitute for the students of an academic study. In no subject are there more volunteers, who take an active part in observing, than in meteorology; but how few of them carry their work beyond the stage of recording observations and taking means. The reason is not lightly to be assigned to their want of capacity to carry on an investigation, but far more, I believe, to the want of knowledge of the objects of investigation and of the means of pursuing them.

Among the agencies which in the past have fostered the knowledge of these subjects, and stimulated its pursuit, there stand out prominently the annual meetings of this association. It was the British Association which in 1842 re-founded the Kew Observatory for the study of the physics of the atmosphere, the earth, and the sun. It was the British Association which promoted the establishment of magnetic observations in many parts of the earth, and in the early sixties secured the most brilliant achievements in the investigation of the atmosphere by means of balloons. I know of no other opportunity of anything like the same potentialities for the writers of papers to meet with the readers, and to confer together about the progress of the sciences in which they are interested.

But its potentialities are not realised. Those of us who are most anxious for the spread of the application of mathematics and physics to the phenomena of astronomy, meteorology, and geophysics have thought that this opportunity could not properly be utilized by crowding together all the papers that deal with such subjects into one day, or possibly two days, so that they can be polished off with the rapidity of an oriental execution. In fact, the opportunity to be polished off is precisely not the opportunity that is wanted. There are some of us who think that a British Association week is not too long for the consideration of the subjects of which a year's abstracts occupy a volume of six hundred pages, and that, if we could extend the opportunity for the consideration of these questions from one or two days to a week, and let those members who are interested form a separate committee to develop and extend these subjects, the British Association, the country, and science would all gain thereby. I venture from this place, in the name of the advancement of science, to make an appeal for the favourable consideration of this suggestion. It is not based upon the depreciation, but upon the highest appreciation of the service which mathematics and physics have rendered, and can still render, to the observational sciences, and upon the well-tried principle that close family ties are strengthened, and not weakened, by making allowance for natural development.

The plea seems to me so natural, and the alternatives so detrimental to the advancement of science in this country, that I can not believe the Association will turn to it a deaf ear.

RECENT ADDITIONS TO THE WEATHER BUREAU LIBRARY.

C. FITZHUGH TALMAN, Librarian.

The following have been selected from among the titles of books recently received, as representing those most likely to be useful to Weather Bureau officials in their meteorological work and studies. Most of them can be lent for a limited time to officials and employees who make application for them. Anonymous publications are indicated by a ——.

Borghese, Gaetano.
Meteorologia e climatologia di Novara di Sicilia. Messina. 1907. 61 p. 8°.

Buitenzorg (Java). Botanical institute.
Observations météorologiques. Année 1907. [Buitenzorg. 1908.] 12 p. f°.

Curityba. Observatorio meteorologico.
Historico sobre os meteorographos Theorell em servico nas estações meteorologicas de repartição geral dos telegraphos. Curityba. 1908. 10 p. 8°. 6 sheets. 33 x 40 cm.

Denmark. Danske meteorologiske Institut.
Meteorologisk Aarbog. 1907. Kjobenhavn. 1908. 144 p. f°.

Finland. Finska vetenskaps-societetens meteorologiska centralanstalt.
Observations météorologiques. Helsingfors. 1908. 126 p. f°.

Fischli, Fritz.
Das Verhalten der meteorologischen Elemente und Erscheinungen in der Vertikalen. Bern. 1908. 129 p. 8°.

Krebs, Wilhelm.
Umschwung der Niederschlagverhältnisse zwischen 1902 und 1908, mit besonderer Berücksichtigung Mitteleuropas. (Sonderabdruck aus der Zeitschrift für Gewässerkunde. 9 Bd. 1 H. p. 64-81.)

Luyken, K.
... Die absoluten erdmagnetischen Beobachtungen der Kerguelen-Station. Berlin. 1908. p. 77-187. f°. (Deutsche südpolar-expedition 1901-1903. VI. Erdmagnetismus II.)

Mizusawa. International latitude observatory.
Annual report. 1907. 1908. 37 p. f°.

Möller, Max.
Zur Theorie der Bewegungsvorgänge. Leipzig. 1907. vii, 86 p. 9°. (Sonderabdruck aus der Zeitschrift "Die Turbine," Organ der Turbinentechnischen Gesellschaft E. V. Jahrgang 1907.)
Wetter-Berather. Anleitung zum Verständniss und zur Vorherbestimmung der Witterung. Hamburg. 1886. 30 p. 8°.
Witterungs-Kalender. Theil 2-3. Erläuterungen. Braunschweig. [1899?] 104 p. 8°.

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Mohn, H[enrik].
Daemringen in Norge. Christiania. 1908. 76 p. 4°. (Videnskabs-Selskabets Skrifter. 1. Mathematisk.-Naturv. Klasse. 1908. No. 5.)

Montessus de Ballore, [Fernand de].
Efectos del terremoto del 18 de abril de 1906... Santiago de Chile. 1907. 34 p. 8°.
Los progresos de la sismolojía moderna. Santiago de Chile. 1907. 20 p. 8°.
Travaux séismologiques du Comte de Montessus de Ballore. n. p. n. d. 4 p. 8°.

Mylius, Ernst.
Volks-Wetterkunde. Witterungstypen und Witterungs-Katechismus für Nord- und Mitteldeutschland. Berlin. 1908. 40 p. 8°.

National antarctic expedition. 1901-1904.
Meteorology. Part 1. Observations at winter quarters and on sledge journeys, with discussion by various authors. London. 1908. xiv, 548 p. f°.
Physical observations, with discussion by various authors. London. 1908. v, 192 p. f°.

[Naturforschender Verein in Brünn.]
Ergebnisse der phaenologischen Beobachtungen aus Mähren und Schlesien... 1905. Brünn. 1907. 16 p. 8°.

Petermanns Mitteilungen.
Inhaltsverzeichnis... 1895-1904. Gotha. 1907. iv, 160 p. 4°.

Royal society of London.
Catalogue of scientific papers 1800-1900. Subject index. v. 1. Pure mathematics. Cambridge. 1908. lviii, 666 p. 4°.
International catalogue of scientific literature. 6th annual issue. F. Meteorology. London. 1908. viii, 257 p. 8°.

Rummler, —.
Ueber die Messung der Windestärke. (33. Städtische Oberrealschule Freiburg, Schl. 33 Jahresbericht. Freiburg, Schl. 1907. p. 1-20. 4°.)

Société ouralienne d'amateurs des sciences naturelles.
Bulletin. Tome 27. Ekatherinbourg. 1908. xix, 122, lviii p. 8°.

Tacubaya. Observatorio astronomico nacional.
Annuario. 1909. Mexico. 1908. 610 p. 12°.

Wall, W. J.
The hyge-donor humidifyer. Montreal. [1907?] 8 p. 24°.

RECENT PAPERS BEARING ON METEOROLOGY AND SEISMOLOGY.

C. FITZHUGH TALMAN, Librarian.

The subjoined titles have been selected from the contents of the periodicals and serials recently received in the Library of the Weather Bureau. The titles selected are of papers or other communications bearing on meteorology or cognate branches of science. This is not a complete index of the meteorological contents of all the journals from which it has been compiled; it shows only the articles that appear to the compiler likely to be of particular interest in connection with the work of the Weather Bureau. Unsigned articles are indicated by a ——

American geographical society. Bulletin. New York. v. 40. Dec., 1908.
—— The forest region of Mount Kenia. p. 745-746. [Includes notes on climate.]
W[ard], R[obert] DeC[ourcy]. Plague and climate. p. 750-751.

California physical geography club. Bulletin. Berkeley. v. 2. Dec., 1908.
Moore, Edward. A cloudburst in the high Sierra. p. 24-27.

Conservation. Washington. v. 14. Dec., 1908.
McGee, W J Bearing of the proposed Appalachian forest on navigation. p. 661-663.

Electrical News. New York. v. 53. Jan. 2, 1909.
Potamian, —. Divisch, a lightning-rod pioneer, 1754. p. 30-33.
—— Effect of the recent drought upon water-power plants. p. 33-35.

Engineering news. New York. v. 60.
Snow, J. P. Forests and stream flow. (Dec. 3, 1908.) p. 619.
Winslow, A. A method for determining the number of dust particles in air. (Dec. 31, 1908.) p. 748.

Mount Weather observatory. Bulletin. Washington. v. 1. pt. 4.
Kimball, H[erbert] H[arvey]. Pyrheliometer and polarimeter observations. p. 207-231.

School science and mathematics. Chicago. v. 9. Jan., 1909.
Jefferson, Mark. Some remarks about the meteorology to be taught in a high-school course in physiography. p. 41-44.

Science. New York. v. 29. Jan., 1909.
Reid, Harry Fielding. Mr. Manson's theory of geological climates. p. 27-29.

Scientific American supplement. New York. v. 47. Jan. 9, 1909.
—— An electric barometer. p. 19.

Terrestrial magnetism and atmospheric electricity. Baltimore. v. 13. Dec., 1908.

Humphreys, W[illiam] J[ackson]. Note on the magnetic effect of winds. p. 153-154.

Aérophile. Paris. 16 année. 15 déc., 1908.

Carton, E. Les perturbations météorologiques et les ballons. p. 505-506.

Ciel et terre. Bruxelles. 29 année. 16 déc., 1908.

Alfani, Guido. Le grand baromètre de l'exposition de Faenza. p. 483-493.

L., E. Les grands baromètres. p. 405-506.

France. Académie des sciences. Comptes rendus. Paris. v. 147. Déc., 1908.

Savornin, J. Sur le régime hydrographique et climatérique algérien depuis l'epoque oligocène. p. 1431-1433.

Arctowski, Henryk. Sur les variations des climats. p. 1438-1440.

Angot, Alfred. Perturbations sismiques du 12 et du 18 décembre 1908. p. 1440-1442.

Société météorologique de France. Annuaire. Paris. 56 année. Sept., 1908.

Angot, Alfred. La vie et les travaux de M. Mascart. p. 229-237.

Durand-Gréville, E. Le premier crêpuscule du matin et le second crêpuscule du soir. p. 238-239.

G., Ch. Chutes de foudre sur les navires. p. 240.

Hansa. Hamburg. 45. Jahrgang. 26. Sept. 1908.

Hermann, E. Kann die drahtlose Telegraphie zur Zeit der modernen Witterungskunde wesentliche Dienste leisten? p. 962-964.

Meteorologische Zeitschrift. Braunschweig. Bd. 25. Dez., 1908.

Hann, J[ulius]. Mossman über die meteorologischen Ergebnisse der Schottischen Antarktischen Expedition. p. 529-542.

Wien, W. Gesetze und Theorien der Strahlung. p. 542-549.

Abbot, C. G., & Fowle, F. E. Die neuesten Untersuchungen über die Solarkonstante der Strahlung. p. 549-552.

Hann, J[ulius]. Ueber den täglichen Gang der Temperatur in den höheren Luftschichten. p. 557-559.

Hann, J[ulius]. Resultate der meteorologischen Beobachtungen in Oberägypten und im Sudan. p. 559-562.

—— Meteorologische Beobachtungen in dem Gebiete der Hudsonbai im Jahre 1905. p. 562.

Voeikov, A. Turkestan. Ist eine fortschreitende Austrocknung Turkestans vorhanden? p. 567-568.

Schuster, Arthur. Die 4.8 jährige Sonnenfleckenperiode. p. 568.

Forel, F. A. Periodische Gletscherschwankungen und ihr Zusammenhang mit den meteorologischen Faktoren. p. 569-570.

Siegel, Franz. Regenmessungen auf den Stationen der Paranáenser Staatsbahn (Estrada de ferro do Paraná) im Jahre 1907. p. 572.

Physikalische Zeitschrift. Leipzig. 9. Jahrgang.

Thorner, Walther. Ueber Tageslichtmessungen. (1 Dez. 1908.) p. 855-858.

Bestelmeyer, A. Luftdruckvariometer zur Messung der Vertikalgeschwindigkeit bei Ballonfahrten. (1 Dez. 1908.) p. 863-864.

Gockel, A., & Wulf, T. H. Beobachtungen über die Radioaktivität der Atmosphäre im Hochgebirge. (15 Dez. 1908.) p. 907-911.

Wetter. Berlin. 25. Jahrgang. November 1908.

Meissner, Otto. Wahrheit und Irrtum in den Bauernregeln. p. 241-247.

Schulze, Paul. Ludwig Friedrich Kämtz. p. 247-250.

Joester, Karl. Die Föhnerscheinungen in Riesengebirge. p. 250-254.

Zeitschrift für Instrumentenkunde. Berlin. 28. Jahrgang. Nov., 1908.

Scheel, K., & Heuse, W. Ueber scheinbare Abweichungen vom Mariotteschen Gesetz und deren Einfluss auf die Messung kleiner Drucke. p. 346-348.

Sociedad científica "Antonio Alzate." Memorias y revista. Mexico. Tome 26.

Diaz, Severo. Un temporal de invierno. (Abril 1908.) p. 359-368.

Descroix, Leon. Perturbations barométriques accidentelles. Relation entre la vitesse et l'amplitude des oscillations orageuses ou cycloniques. (Junio 1908.) p. 481-483.

THE BALTIMORE MEETING OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

By WM. R. BLAIR, Research Director. Dated Mount Weather, Va., January 14, 1909.

Of the papers given before the American Physical Society and Section B of the American Association for the Advancement of Science three were of sufficiently direct interest to meteorologists to be reviewed here. Prof. R. DeC. Ward's paper on the cyclonic unit in climatological investigations was withdrawn[1] from the program of the Geographical Section.

The paper on the diurnal variations in the intensity of the penetrating radiation present at the surface of the earth by A. Galline was read by Professor McLennan of Toronto University. The experimental work on which this paper was based was undertaken because work done by Strong and one or two other experimenters seemed to indicate: 1. That the air and not the earth was the source of the radiation in question; and 2. That the radiation had a diurnal variation in intensity. The Wilson electroscope was used in the experiments. Several series of data were shown in which measurements were made of the conductivity of the air near the surface (1) of the earth, and (2) of the lake (on the ice). It was found that the value of the conductivity of the air over the lake was consistently less than 50 per cent of that over the earth's surface. This result showed, Professor McLennan thought, that the source of the penetrating radiation was in the earth rather than in the air, the reason for the lower values over the lake being the screening effect of the water. Laboratory experiments on the screening effects of water had also been made in support of this view. Other series of data showing hourly observations on the conductivity of the air for periods of twenty-four hours showed the variations in its value during any one day were never greater than the errors of the observations themselves and plots of these data gave no indication of any periodic variation whatever.

The two sets of data above mentioned are remarkably consistent and seem to support each other and the conclusion that the earth is the source of the penetrating radiation and that the radiation does not have a diurnal variation in intensity sufficiently marked to be detected with the apparatus used, i. e., if such a variation exists it is less than 2 per cent of the total radiation.

Doctor Bauer, of the Carnegie Institution, made an eloquent plea for terrestrial and cosmical physics. He set forth interesting and practical problems in this field of applied physics and contrasted the attention given it in the European countries and our own. In England, for example, a very considerable part of the program at such a meeting as the one before which the plea was being made would be devoted to terrestrial and cosmical physics, while here a very small number of papers dealing with subjects in this field appear. A separate section in the American Association for the Advancement of Science was not advocated. The purpose of Doctor Bauer's address was to commend to the men and the laboratories of our universities the above-mentioned problems.

In the nature of things such a plea as this could not help the cause much, if any, when presented to men who have chosen other lines of work and have come together to exchange ideas with those working in the same related fields as themselves. Some of us at work in this particular field of applied physics find it most interesting and do not feel that it needs this sort of plea. We can not expect all physicists to be interested in it, but to those who are or may become so the best inducement for them to take up its problems is the presentation from time to time of the work itself as it develops.

The upper inversion in the atmosphere was again spoken of by Prof. W. J. Humphreys. This time no reference was made to the moisture content of the inversion layer. It was assumed that the base of the upper inversion marks the upper boundary of vertical currents in our atmosphere. This is the opinion held by Teisserenc de Bort and has been given by him as the cause of the temperature inversion. Others hold the presence of vertical currents below the coldest point reached and their absence above it to be a necessary result of the temperatures obtaining. The probable mean temperature of the effective radiating surface of the earth, which Abbot and Fowle put at fully 4,000 meters above sea-level, has been determined by them to be 263° absolute temperature or —10° C. (14° F.). Using this result with the above consideration Professor Humphreys computed the temperature at the turning point in the gradient, i. e., at the base of the upper inversion

[1] See notice of Association of American Geographers.

layer. The result obtained in the case taken was in good agreement with the experimental data.

It must be borne in mind that, while the base of this layer seems always to be quite well marked, its temperature varies by as much as 20° C. in a day or two and the altitude at which it is found by as much as 4,000 meters or about 2½ miles in the same time.

THE BALTIMORE MEETING OF THE ASSOCIATION OF AMERICAN GEOGRAPHERS.

At the meeting of the Association of American Geographers held at Baltimore, Md., January 1 and 2, 1909, the following papers of interest to our readers were presented:

Mr. A. Lawrence Rotch spoke on the temperature at great heights above the American Continent.

Prof. R. DeC. Ward, on the cyclonic unit in climatological investigations, as follows:

Climatology has been too much concerned with monthly, seasonal, and annual averages. These summaries being based on final and definite periods, do not bring out the variations of the climatic elements under cyclonic and anticyclonic control, yet the irregular cyclonic and cyclonic changes are the very ones which most affect man. An important addition to the usual climatic summaries would be the introduction for all regions in which the cyclonic or storm control of weather conditions is characteristic, of the cyclonic unit, so that, for example, the average duration and value of cyclonic ranges of temperature in the several months, or the proportion of rain and snowfall received from cyclonic storms, or from local thunderstorms, might be determined.

Prof. Ellsworth Huntington on the climate of the historic past in the Americas, to appear in the next number of the MONTHLY WEATHER REVIEW.

Mr. Henry Gannett spoke on the climate of Cuba.

On December 31, 1908, Prof. Albrecht Penck of the University of Berlin, Kaiser Wilhelm Exchange Professor, gave a lecture on "The relation between climate, soil, and man," of which we hope to print an abstract in a later number.—*C. A., jr.*

NOTES FROM THE WEATHER BUREAU LIBRARY.

C. FITZHUGH TALMAN, Librarian.

JOSEPH MARIA PERNTER, 1848-1908.

We regret to report the death of the eminent Austrian physicist and meteorologist, Hofrat Prof. Dr. Josef Maria Pernter, on December 20, 1908, at Arco, after a long and painful illness. Professor Pernter was the director of the Austrian Central Institution for Meteorology and Geodynamics, Hohe Warte, Vienna; a member of the International Meteorological Committee, and Vice President of the Imperial Royal Austrian Society for Meteorology. He was born March 15, 1848, at Neumarkt, in the Tyrol, was educated at Innsbruck and Vienna, and has past most of his life in the service of the Austrian Central Institution for Meteorology, of which he became director in 1897, on the retirement of Hann. While his writings, published mostly as memoirs and notes in the scientific journals, have covered a wide range of meteorological subjects, his favorite field was atmospheric optics. In 1902 he began the publication of his "Meteorologische Optik," announcing that the work would be completed, in four parts, within a year. This expectation was unfortunately not realized, and but three parts, comprising 558 octavo pages, have been published to the present time. We are glad to learn, however, thru a private letter, that the completion of this important work, which is the only modern treatise covering the whole field of atmospheric optics, has been undertaken by Dr. Felix Exner, who was one of the late Professor Pernter's assistants at Vienna.

THE RAINFALL OF ITALY.[1]

It will be remembered that at the Paris meeting of the International Meteorological Committee, in 1907, special prominence was given to the question of compiling and publishing the data collected over a long period of years by the meteorological services of the world. A list of the publications of this character already issued or in contemplation was given in an appendix to the report of the meeting, and constitutes a bibliography of great value to meteorologists and climatologists.

Under the head of Italy it was announced that a compilation of the precipitation data embracing the period 1880–1905 was in preparation. This work, which has now appeared, is a folio volume of 315 pages, together with seventeen colored plates showing the normal monthly, seasonal, and yearly distribution of rainfall over the whole of Italy, including Sicily and Sardinia. The tables give for each of 215 stations the monthly amount of rainfall and frequency of rainy days (i. e., days with 0.1 millimeter or more) during every year of observation within the period stated. All of these stations have long records, almost or quite coextensive with the period under discussion, hence no reductions have been applied to render the series homogeneous as to time. Other features of the work are a description of the annual march of the amount and the frequency of precipitation, six types of each being distinguished, and a discussion of the influence of topography upon the amount of precipitation.

The author, Dr. Filippo Eredia, has taken great pains to correct doubtful figures by correspondence with the observers, and he states that the figures he gives are to be considered authoritative in the case of discrepancies between this and earlier publications. The principal object of the present work is to bring out the geographical distribution of the rainfall in Italy; another work, now in preparation, will present statistics covering a longer period of time and exhibit especially the variability of the rainfall.

WORLD-WIDE RELATIONS OF THE INDIAN MONSOON RAINFALL.

The Annual Report for 1906–7 of the Board of Scientific Advice for India discusses *inter alia* the researches lately made into the connection between meteorological conditions in various parts of the world in the period preceding the Indian monsoon, and the amount of rainfall therein to be expected. A study of the statistics at present available seems to show that the conditions most closely associated with abundant monsoon rains are: low pressure at Mauritius in the preceding May, deficient subequatorial rainfall in May as given by Zanzibar and the Seychelles, deficient snowfall in May, and high pressure in India during the previous year. A formula has been worked out for calculating the monsoon rainfall departures, and on applying this to successive years from 1875 onward it is found that of the years with a forecasted departure of more than one inch, the sign of the departure has been correctly estimated in twenty cases out of twenty-four. An important relationship seems to have been established between pressure at Mauritius and the position of the trough of low pressure in upper India in June, July, and August.

The report also refers to results of investigations of the upper air by means of kites. On July 17, 1907, the highest kite ascent yet made in India (12,000 feet) was effected at Belgaum with good results, but soon afterwards the conditions became prohibitive of further attempts. The dry layer which had sometimes been found to occur in 1906, at heights between 2,500 and 8,300 feet, was found only once in 1907 at a height of about 5,000 feet. Kite flying during the monsoon has proved more difficult than had been anticipated, and work with sounding balloons has also to encounter obstacles. It has shown, however, that tho there is always a large westerly component in the upper air current above Simla, it is not so constant either in direction or velocity as might have been imagined.—*Geographical Journal, January, 1909.*

BRITISH NATIONAL ANTARCTIC EXPEDITION, 1901-1904.

The Royal Society has published, in a substantial and handsome volume, the chief part of the results of the meteorologi-

[1] Eredia, Filippo. Le precipitazioni atmosferiche in Italia dal 1880 al 1905. Roma, 1908. (Estratto dagli Annali dell'Ufficio Centrale Meteorologico e Geodinamico italiano, vol. 25, parte 1, 1905.)

cal observations of the British National Antarctic Expedition, commanded by Commander R. F. Scott, R. N., which left Cowes in August, 1901, and returned to Spithead in September, 1904.[1] This volume has been prepared under the superintendence of Doctor Shaw, Director of the Meteorological Office, with the cooperation of a committee of the Royal Society; and several eminent British meteorologists, official and otherwise, contribute to the discussion of the several kinds of observations. An extended review of this publication appears in Nature of December 17, 1908. The expedition has rendered a splendid service to meteorology in obtaining two years of continuous observations at a station far within the Antarctic Circle (lat. 77° 50′ 50″ S.).

Especially timely and interesting is Doctor Shaw's review of the question as to the existence of a permanent anticyclone over the South Polar Continent (p. x-xiv). This question remains unsettled.

AEROLOGICAL EXPEDITION TO EAST AFRICA.

Das Wetter announces that the aerological expedition of the Royal Aeronautical Observatory at Lindenberg, to the Victoria Nyanza and the coast of East Africa, fitted out at the expense of Messrs. W. Tepelmann, Brunswick (Friedr. Vieweg & Sohn); Prinzhorn, of the Continental Caoutchouc and Gutta Percha Company, Hanover; Arnhold, Berlin; and von Guillaume, Cologne, sailed in June under the conduct of Professor Berson, of Lindenberg, Doctor Elias, of Berlin, and balloon inspector Mund, of the aeronautical observatory. It was to have returned at the end of December, after having made a series of ascensions on Victoria Lake and on the east coast of Africa from Mombassa to Delagoa Bay, with kites, registering balloons, and pilot balloons—the latter up to a height of 22,000 meters. Most important data have been obtained on the monsoon winds and the processes in the upper layers of the atmosphere, in the interior of Africa, under the equator, and on the Indian Ocean.

TORNADOES IN ARKANSAS DURING NOVEMBER, 1908.

At 8 a. m. November 23, 1908, a small low of moderate intensity (pressure 29.65 inches at center) was central over the northwestern corner of Arkansas. Rain had recently fallen, or was falling, over the northern two-thirds of Kansas and over eastern Oklahoma, with thunderstorms at Little Rock, Ark., and Memphis, Tenn. Southerly and southeasterly winds prevailed over the States bordering the lower Mississippi on the west.

This low (No. 1) moved northeastward, rapidly increasing in intensity, and by 8 a. m. of the 24th its center was over Des Moines, Iowa, with a pressure of 29.35 inches, or lower. Simultaneously a second and almost equally intense low (No. 2) had developed over southeastern Utah, accompanied by snow in the southeastern quadrant. The whole Mississippi Valley was included in the rain area of the low No. 1, and a number of thunderstorms occurred in its southeastern quadrant.

By 8 a. m. of the 25th the low No. 2 had moved south-southeastward into Texas and then turned northeastward to a position central over Dodge City, Kans., with a pressure of 29.40 inches, while low No. 1 had moved northward but a short distance to Duluth, Minn. The whole country, except for the Atlantic and Gulf shores, was involved in rain, and a belt of thunderstorms reached from Dodge City, Kans., to Milwaukee, Wis.

Tornadoes of November 23, 1908.

The weather conditions outlined above proved particularly favorable for the development of tornadoes in Oklahoma, western Arkansas, and southern Missouri during the afternoon and evening of November 23, and again in eastern Arkansas on the afternoon of November 25. Except for local deflections due to local topographic features, the tornadoes travelled from the southwest to the northeast in all cases, as shown by the map, fig 1. There seem to have been two and perhaps three distinct periods of tornado development on the 23d.

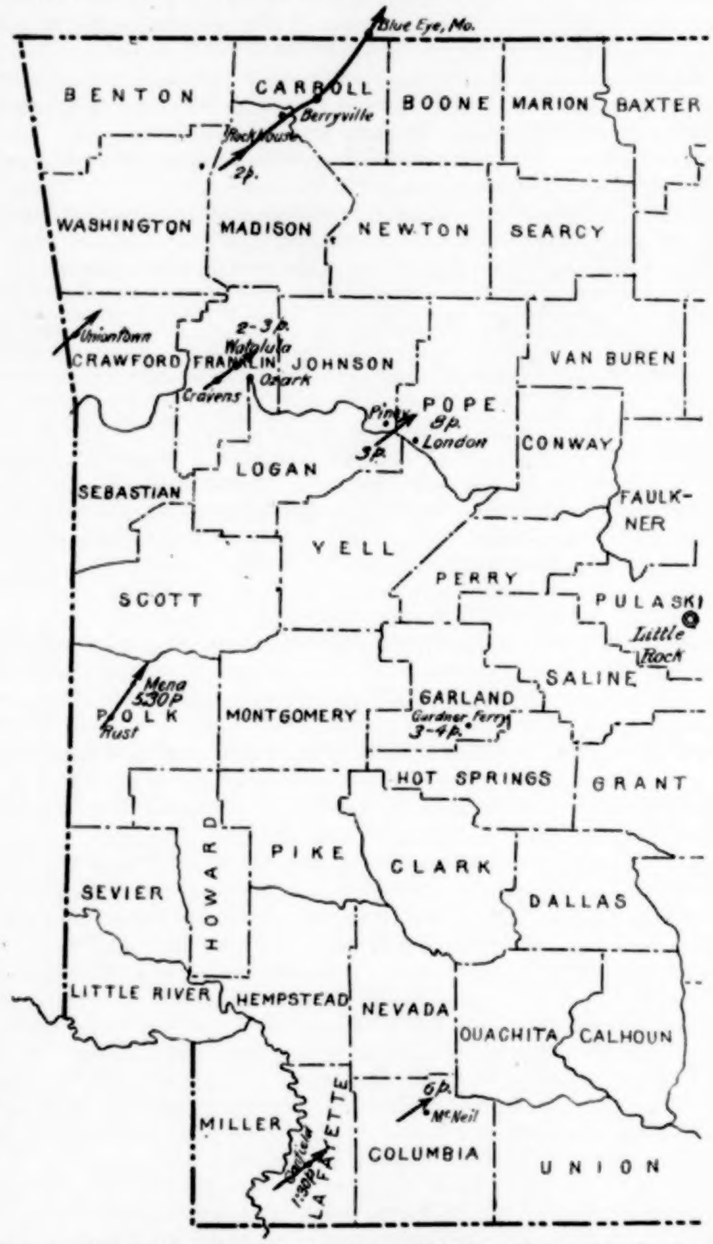


FIG. 1.—Tracks of tornadoes in western Arkansas November 23, 1908.

The earliest reported occurrences came between 1:30 and 2 p. m. Canfield, Lafayette County., Ark., was visited at 1:30 p. m. by a tornado moving from southwest to northeast, which destroyed $1,500 of property, over a path about one-fourth mile wide, and injured four persons, none fatally. At about 2 p. m. a tornado passed 15 miles northwest of Huntsville, Madison County, Ark., traveling in the same general direction along a path one-fourth mile wide. It did much damage near Huntsville and slightly injured several persons. This same tornado evidently continued past Rock House into Carroll County, Ark., causing damage to the amount of $50,000 in the vicinity of Berryville, Carroll County, which it reached at 2:15 p. m.; it past out of the State into Missouri at Blue Eye, Stone County, Mo., and there blew away a school house without injuring the

[1] National antarctic expedition, 1901-1904. Meteorology, part 1. Observations at winter quarters and on sledge journeys, with discussions by various authors. Prepared under the superintendence of the Director of the Meteorological Office with the cooperation of a committee of the Royal Society. London, 1908.

school children then in it. No further reports of this storm have been received. Its path was 150 yards wide at Berryville.

Between 2 and 3 p. m. a severe tornado, with a path 30 yards wide, struck Cravens, Franklin County, Ark , destroying many buildings, killing four persons and injuring many others. This same storm killed fourteen persons at Watalula and injured several at Jethro, Franklin County, Ark., before it died out within 20 miles of the latter place.

Between 3 and 4 p. m. another tornado past northeastward and eastward along the Arkansas River between Piney, Johnson County, Ark., and London, Pope County, Ark., destroying much timber, several farm-houses, and injuring thirty or forty persons. The path of this storm was about 300 yards wide. The damage is estimated at $25,000. About the same time a tornado in Garland County, Ark., struck the small frame schoolhouse at Gardener Ferry, lifted it with the assembled school and set all down unhurt 20 feet distant. Another tornado past northeastward thru Crawford County, Ark., about one-half mile north of Uniontown, and mowed a clean path about 100 yards wide thru the forests and across farms. A number of small houses were demolished and one farmer was injured.

At 5 p. m. a tornado past 1 mile north of Rust, Polk County, Ark., and shortly afterward past thru the northern part of Mena, about 5 miles from Rust. Two persons were reported killed and three injured at Rust. At Mena two houses were wrecked and four or five persons injured. This storm had a path 50 to 100 yards wide and was followed by heavy hail. The damage was estimated at $5,000. At 6 p. m. a tornado past 1 mile north of McNeil, Columbia County, Ark., but at the time it was too dark to see the funnel-shaped cloud. Its path was about 150 yards wide and it destroyed houses and fencing to the value of $400 without injuring any persons. The indicated path of this tornado would seem to be a continuation of the one reported at Canfield at 1:30 p. m. the same day.

Tornado of November 25, 1908.

On November 25 a severe tornado traversed Green County, in northeastern Arkansas, from southwest to northeast. The The first report was from Lorado, near the southern line of the county. The tornado appeared here between 3:30 and 4 p. m., moved northeastward with a destructive path 75 to 150 yards wide and about 5 miles long. One child was killed and four other persons injured, the 3-room school building had one end blown outward from bottom to top, and two churches and a parsonage were also wrecked. The damage was estimated at $30,000. The storm continued to a point 2 miles east of Walcott, having there a path about 50 yards wide. Here one boy was killed and five adults injured, while damage to the extent of $20,000 was reported. Newspaper reports indicate considerable damage in the more rural districts from which no direct reports are available.

TORNADO IN OKLAHOMA.

Newspaper clippings report that a tornado past over the North Flats, near the Holmes Ranch, 30 miles northeast of Kenton, Okla., along the New Mexico–Oklahoma boundary, on November 23. Many piles of lumber were carried 50 miles from the South Flat region and dropt over the North Flats.—*C. A., jr.*

THE WEATHER OF THE MONTH.

By Mr. P. C. DAY, Acting Chief, Climatological Division.

PRESSURE AND WINDS.

The distribution of the mean atmospheric pressure for December, 1908, over the United States and Canada, is graphically shown on Chart VI, and the average values and departures from the normal are shown for each station in Tables I and III.

The variations of the mean pressure for the month from the December normal were not marked by any special features. Comparatively high pressure dominated the Gulf States, and the usual winter area of high pressure over the central Rocky Mountain district and thence westward to the Pacific, was somewhat more pronounced than usual.

The average pressure for the month was below the normal from the Missouri Valley eastward and southeastward to the Atlantic coast, while from Texas westward and northwestward to the Pacific coast, it was above the normal, the maximum excesses, .05 to .15 inch, embracing the Rocky Mountain region from southern New Mexico to British Columbia.

As in the preceding month the continued prevalence of moderately high pressure over the mountain districts was unfavorable to the formation of storm centers over those regions, and the majority of the low areas that developed during the month appear to have had their origin on the Great Plains of the Canadian Northwest.

The high pressure along the eastern slope of the Rocky Mountains and over the southern portions of the Great Plains, was probably instrumental in confining the storms that developed over the Canadian Northwest to the northern circuit in their progress eastward.

As a result but few storm centers crost the interior portions of the United States and the month, as a whole, was remarkably free from adverse weather conditions.

With high pressure over the Rocky Mountain region and thence southeasterly to the lower Mississippi Valley, the districts to the northeast were under the influence of frequent warm southerly winds. In the middle and southern Rocky Mountain, Plateau, and Pacific coast districts, cold northerly winds were of frequent occurrence.

TEMPERATURE.

The month of December, 1908, opened with an extensive area of high pressure covering the northwest, accompanied by the first well-marked cold wave of the season. Temperatures from zero to 10° below were reported on the mornings of the 1st and 2d from points in the upper Missouri Valley, and the cold area gradually overspread the eastern and southern districts during the 3d and 4th. A second cold wave appeared over the upper Missouri Valley on the morning of the 6th, with temperatures from 10° to 20° below zero over northern Minnesota, North Dakota, and Montana, and moved rapidly southeastward to the south Atlantic and Gulf coasts by the 8th. Moderate temperatures prevailed from the last-named date till about the 30th, when cold weather again set in over the northern Rocky Mountain district, and at the end of the year had overspread the district from the Rocky Mountains eastward to the Mississippi and Ohio valleys and Lake region, with temperatures from 10° to 20° below zero along the northern border from the upper Lakes westward to eastern Montana on the morning of the 31st.

During the first decade the mean temperature ranged from 4° to 10° below the normal over most of the interior districts, but was generally above normal along the Atlantic and Gulf coasts, the Mexican border, and generally over the Pacific coast States. Unusually high temperatures prevailed on the 1st along the immediate Atlantic and Gulf coasts, where temperatures as high or higher than previously recorded during the first decade of December occurred.

During the second decade the mean temperature was above the normal from 3° to 10° over all interior districts from the Rocky Mountains eastward, while over the western district it ranged from 3° to 7° below. From the 16th to the 18th some unusually high maximum temperatures occurred over the

more southern districts from the central portions of Texas and Oklahoma eastward to the Atlantic.

During the third decade the mean temperature was above the normal over practically all districts, the excess being greatest over the interior valleys east of the Rocky Mountains, where the mean ranged from 5° to 11° above the average.

As a whole the mean temperature for the month was above the normal over all districts east of the Rocky Mountains, except locally in the upper Lake region and along the New England coast, and it was generally below normal over the districts west of the Great Divide, except over the southern portions of New Mexico and Arizona.

Maximum temperatures above 80° were confined to the southern portions of the Gulf States, and freezing temperatures were reported from all districts, except along the immediate south Atlantic, Gulf, and Pacific coasts. Minimum temperatures from zero to more than 20°, and at exposed points to more than 30° below, occurred over interior New England, in the upper Mississippi and Missouri valleys, and in the Rocky Mountain districts from northern Arizona to Montana.

PRECIPITATION.

Precipitation from 4 to 8 inches occurred over a rather narrow strip from central Virginia and southern West Virginia southwestward to central Louisiana, and amounts from 2 to 4 inches were general over the remainder of the districts from the lower Mississippi Valley eastward to the Atlantic and northeastward over the Ohio Valley, the lower Lake region, and New England, except over the Florida Peninsula, where the amount of fall was generally less than 1 inch, and along the west coast of that State less than half an inch occurred.

Over portions of the upper Mississippi Valley, the Missouri Valley, and the Great Plains the precipitation was less than 1 inch, and over portions of western Kansas, the greater part of Oklahoma and western Texas, and the eastern portions of Colorado and New Mexico there was practically no precipitation.

Some unusually heavy rains occurred in southwestern Arizona, and the amount of precipitation from rain and melted snow was heavy over the greater part of the Territory.

More than the usual amount of precipitation occurred from the lower Mississippi Valley northeastward to southern New England, at a few points in the Lake region and central Texas, and from eastern South Dakota southwestward over a narrow strip to southern Arizona. Over the remaining districts there was less than the average amount of precipitation, the deficiency being greatest over the southern portions of the Gulf States, the middle Mississippi Valley, and along the Pacific coast.

SNOWFALL.

Snow occurred in measurable quantities over nearly all districts, except from Texas eastward over the Gulf States, and at the lower elevations of Arizona, California, and Oregon.

An unusually heavy fall of snow for the district and season occurred on the 22d and 23d along the eastern foothills of the Appalachian Mountains, and at the lower elevations from northern North Carolina northeasterly thru central Virginia, and eastern and southern Maryland to New Jersey, where local falls of from 8 to 20 inches occurred.

Some heavy falls occurred in the Adirondack regions of New York and snow was generally heavy over the northern and central portions of the Lower Michigan Peninsula.

Heavy snows occurred on the western slopes of the mountains of Colorado and Wyoming and over portions of northern Arizona, and it appears to have been largely drifted into the ravines and in condition to remain unmelted until late in the season.

Over the northern portion of the Rocky Mountain region there was generally less snow than usual and similar conditions prevailed in the mountains of California, Oregon, and Washington. In the mountain districts of Utah snow had accumulated to considerable depths and its condition was such as to indicate a good supply of water late in the season.

At the end of the month the snow covering was confined principally to the Rocky Mountain region, and from the upper Missouri Valley eastward over the Lake region, portions of northern Pennsylvania, and the interior of New York and New England, with small amounts locally in the Appalachian Mountain district as far south as central Virginia. Over the Sierra Nevada and Cascade ranges the snow remaining on the ground was confined to the high elevations, the lower levels of the mountains being generally bare of snow.

HUMIDITY AND SUNSHINE.

Over the districts from western Texas eastward to the Atlantic and northeastward over the lower Missouri and upper Mississippi valleys, Lake region, and New England the average humidity was below the normal. From the upper Missouri Valley westward and southwestward to the Pacific there was a general excess of humidity, ranging from 8 to 15 per cent in portions of North Dakota and Montana and the southern portions of the Rocky Mountain and Plateau districts.

There was a general excess of cloudy weather over the Atlantic coast districts, from New England to Florida, over portions of the Ohio Valley, and generally in the Lake region, where the amount of sunshine ranged from 30 to less than 10 per cent of the possible. Cloudy weather was also general over large portions of the districts from the Rocky Mountains westward.

Over the Great Plains, lower Missouri and middle Mississippi valleys, there was much sunshine, and outdoor occupations were pursued with few interruptions on account of inclement weather.

In Canada.—Director R. F. Stupart says:

The temperature was above the average at Dawson City, in the Yukon Territory, below in British Columbia and in the northern portions of Alberta and Saskatchewan, above elsewhere in the Western Provinces and over most of the Ontario Peninsula, average or below in the other portions of Ontario, and below average in Quebec and the Maritime Provinces.

In the Yukon Territory, Dawson City recorded 22 inches of snow, which is exactly twice as much as the average quantity. In British Columbia the precipitation was everywhere less than usual, varying from .90 of an inch at Kamloops, to 4.88 inches at Victoria. In Alberta the negative departure was from 59 to 82 per cent. In Saskatchewan, in the vicinity of Prince Albert, the snowfall appears to have been much more than the general amount, but elsewhere in the Province there was a deficiency equivalent to from 70 to 88 per cent. In Manitoba the deficit was from 36 to 70 per cent. In Ontario, over Lake Superior and from the Ottawa Valley eastward, there was a marked positive departure, while in the Peninsula the negative departure was equal to 1 inch at Kingston, and less elsewhere. In Quebec the average was well exceeded, except apparently in the extreme eastern portion. Montreal recorded a positive departure of more than 2 inches. In the Maritime Provinces the precipitation was above the average, the positive departures varying from 1.43 inches at St. John, to 2.64 inches at Halifax.

At the close of the month, the ground thruout Canada was, as a general rule, snow-covered, altho in some sections, notably southern Alberta, southern Ontario, and in Nova Scotia, the ground was practically bare of snow.

The higher levels of British Columbia were probably well covered with snow, and in that portion of the Western Provinces which was snow-covered, the depth varied between 4 and 14 inches.

In Ontario the mantle of snow varied in depth from a trace in the south, to about 24 inches in the Georgian Bay and upper Ottawa Valley. Quebec was snow-covered to a depth of from 20 inches in the western districts, to 38 inches in the east. The depth of snow in the Maritime Provinces decreased from about 20 inches in northern New Brunswick, to a trace near the Bay of Fundy.

Average temperatures and departures from the normal.

Districts.	Number of stations.	Average temperatures for the current month.	Departures for the current month.	Accumulated departures since January 1.	Average departures since January 1.
		°	°	°	°
New England	12	29.6	0.0	+ 9.9	+ 0.8
Middle Atlantic	16	35.9	+ 1.2	+ 6.1	+ 0.5
South Atlantic	10	51.1	+ 4.0	+13.0	+ 1.1
Florida Peninsula*	8	64.8	+ 4.2	+10.2	+ 0.8
East Gulf	11	53.7	+ 4.6	+15.5	+ 1.3
West Gulf	10	51.9	+ 3.5	+17.8	+ 1.5
Ohio Valley and Tennessee	13	39.3	+ 2.2	+17.3	+ 1.4
Lower Lake	10	29.2	− 0.1	+ 9.4	+ 0.8
Upper Lake	12	24.2	− 0.1	+22.3	+ 1.9
North Dakota*	9	14.0	+ 1.4	+27.6	+ 2.3
Upper Mississippi Valley	15	29.6	+ 2.3	+21.2	+ 1.8
Missouri Valley	12	30.9	+ 4.0	+28.0	+ 2.3
Northern Slope	9	25.0	+ 1.3	+11.2	+ 0.9
Middle Slope	6	35.9	+ 3.0	+15.1	+ 1.3
Southern Slope*	7	45.1	+ 2.7	+ 7.6	+ 0.6
Southern Plateau*	12	40.8	− 0.4	− 7.7	− 0.6
Middle Plateau*	10	24.6	− 3.2	−11.4	− 1.0
Northern Plateau*	12	28.6	− 1.9	+ 5.3	+ 0.4
North Pacific	7	40.1	− 1.5	− 0.8	− 0.1
Middle Pacific	8	44.5	− 3.8	− 4.7	− 0.4
South Pacific	4	50.3	− 2.3	+ 1.5	+ 0.1

* Regular Weather Bureau and selected cooperative stations.

Average relative humidity and departures from the normal.

Districts.	Average.	Departure from the normal.	Districts.	Average.	Departure from the normal.
New England	72	− 4	Missouri Valley	73	− 2
Middle Atlantic	73	− 2	Northern Slope	76	+ 8
South Atlantic	78	0	Middle Slope	67	+ 1
Florida Peninsula	82	+ 1	Southern Slope	62	− 4
East Gulf	76	− 1	Southern Plateau	61	+15
West Gulf	74	0	Middle Plateau	72	+ 2
Ohio Valley and Tennessee	75	− 1	Northern Plateau	80	0
Lower Lake	77	− 1	North Pacific	87	+ 1
Upper Lake	80	− 2	Middle Pacific	84	+ 3
North Dakota	88	+ 9	South Pacific	70	+ 1
Upper Mississippi Valley	74	− 4			

Average cloudiness and departures from the normal.

Districts.	Average.	Departure from the normal.	Districts.	Average.	Departure from the normal.
New England	6.5	+ 0.7	Missouri Valley	4.5	− 0.6
Middle Atlantic	6.3	+ 0.9	Northern Slope	5.5	+ 0.9
South Atlantic	5.4	+ 0.7	Middle Slope	4.0	0.0
Florida Peninsula	4.4	− 0.2	Southern Slope	5.2	+ 0.8
East Gulf	5.8	+ 0.6	Southern Plateau	4.0	+ 1.0
West Gulf	5.4	+ 0.1	Middle Plateau	4.8	− 0.3
Ohio Valley and Tennessee	6.5	+ 0.4	Northern Plateau	7.6	+ 0.5
Lower Lake	7.7	+ 0.1	North Pacific	7.5	+ 0.2
Upper Lake	7.7	+ 0.6	Middle Pacific	6.0	+ 0.6
North Dakota	5.4	+ 0.2	South Pacific	5.3	+ 0.9
Upper Mississippi Valley	5.4	− 0.3			

Average precipitation and departures from the normal.

Districts.	Number of stations.	Average.		Departure.	
		Current month.	Percentage of normal.	Current month.	Accumulated since Jan. 1.
		Inches.		*Inches.*	*Inches.*
New England	12	3.36	103	+ 0.1	− 7.6
Middle Atlantic	16	3.02	97	− 0.1	− 3.4
South Atlantic	10	2.65	73	− 1.0	− 0.2
Florida Peninsula*	8	0.94	36	− 1.7	− 2.8
East Gulf	11	3.27	73	− 1.2	− 5.4
West Gulf	10	1.59	55	− 1.3	− 0.1
Ohio Valley and Tennessee	13	2.64	77	− 0.8	− 7.0
Lower Lake	10	2.00	69	− 0.9	− 5.1
Upper Lake	12	1.52	72	− 0.6	− 3.5
North Dakota*	9	0.34	63	− 0.2	+ 0.9
Upper Mississippi Valley	15	1.01	53	− 0.9	− 2.0
Missouri Valley	12	0.63	61	− 0.4	+ 4.4
Northern Slope	9	0.52	63	− 0.3	+ 3.2
Middle Slope	6	0.13	18	− 0.6	+ 5.9
Southern Slope*	7	0.04	4	− 1.0	+ 5.2
Southern Plateau*	12	1.26	76	− 0.4	− 0.7
Middle Plateau*	10	1.05	100	0.0	+ 1.1
Northern Plateau*	12	0.76	46	− 0.9	− 2.4
North Pacific	7	5.67	72	− 2.2	− 7.5
Middle Pacific	8	2.69	59	− 1.9	− 7.5
South Pacific	4	1.00	85	− 1.2	− 2.9

* Regular Weather Bureau and selected cooperative stations.

Maximum wind velocities.

Stations.	Date.	Velocity.	Direction.	Stations.	Date.	Velocity.	Direction.
Atlanta, Ga	25	50	nw.	Nantucket, Mass	23	60	ne.
Bismarck, N. Dak	29	52	nw.	New York, N. Y	18	50	nw.
Do	30	60	nw.	North Head, Wash	7	56	se.
Block Island, R. I	2	50	nw.	Do	8	58	se.
Do	7	57	w.	Do	11	65	s.
Do	18	52	nw.	Do	12	74	s.
Do	23	57	ne.	Do	15	62	se.
Buffalo, N. Y	1	61	sw.	Do	24	60	s.
Do	7	60	w.	Do	25	72	s.
Do	27	54	w.	Do	27	60	s.
Do	31	52	w.	Point Reyes Light, Cal	16	71	nw.
Canton, N. Y	1	65	w.	Do	31	55	s.
Cheyenne, Wyo	24	52	nw.	Portland, Me	7	56	se.
Chicago, Ill	30	52	w.	Pueblo, Colo	24	59	nw.
Eastport, Me	7	60	se.	Sioux City, Iowa	30	50	nw.
Grand Haven, Mich	7	51	nw.	Southeast Farallon, Cal	16	52	nw.
Hatteras, N. C	23	52	nw.	Tatoosh Island, Wash	1	50	e.
Do	25	61	w.	Do	11	53	s.
Mount Tamalpais, Cal	16	52	nw.	Do	12	84	sw.
Mount Weather, Va	2	56	nw.	Do	13	52	sw.
Do	7	54	nw.	Do	25	90	sw.
Do	18	52	nw.	Do	26	52	sw.
Do	26	60	nw.	Do	28	50	sw.
Do	31	57	nw.	Do	31	62	e.
Nantucket, Mass	7	53	s.				

CLIMATOLOGICAL SUMMARY.

By Mr. P. C. DAY, Assistant Chief, Climatological Division.

TEMPERATURE AND PRECIPITATION BY SECTIONS, DECEMBER, 1908.

In the following table are given, for the various sections of the Climatological Service of the Weather Bureau, the average temperature and rainfall, the stations reporting the highest and lowest temperatures with dates of occurrence, the stations reporting greatest and least monthly precipitation, and other data, as indicated by the several headings.

The mean temperatures for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperature and precipitation are based only on records from stations that have ten or more years of observation. Of course the number of such records is smaller than the total number of stations.

Section.	Temperature—in degrees Fahrenheit.								Precipitation—in inches and hundredths.					
	Section average.	Departure from the normal.	Monthly extremes.						Section average.	Departure from the normal.	Greatest monthly.		Least monthly.	
			Station.	Highest.	Date.	Station.	Lowest.	Date.			Station.	Amount.	Station.	Amount.
Alabama	50.6	+ 4.6	Flomaton	84	16	Riverton	18	2	5.02	+ 0.33	Cedar Bluff	11.22	Lucy	0.96
Arizona	45.9	0.0	Aztec; Mohawk Summit	85; 85	13; 9	Flagstaff	−14	18	2.96	+ 1.98	Pinal Ranch	7.62	Benson	0.71
Arkansas	46.0	+ 4.0	Pine Bluff; Texarkana	82; 82	15; 16	Bergman; Dodd City	11	2	1.50	− 2.42	Huttig	5.30	Fort Smith	0.09
California	43.2	− 3.3	Gold Run	87	28	Alturas	−23	18	2.33	− 1.78	Monumental	12.44	3 stations	0.00
Colorado	23.1	− 2.2	Hoehne	77	23	Kremmling; Wagon Wheel Gap	−38; −38	21; 19	1.31	+ 0.08	Dolores	7.52	Las Animas	0.00
Florida	62.9	+ 4.1	Orange City	93	1	Johnstown	24	28	1.02	− 2.08	Rockledge	2.88	Plant City	0.00
Georgia	51.9	+ 5.4	St. Marys	88	1	Diamond; Tallapoosa	21; 21	3, 4; 8	3.75	+ 0.37	Rome	9.00	St. Marys	0.44
Hawaii (November)	70.6*	......	Pahala, Hawaii; Kihei, Maui	90; 90	28; 4, 26	Humuula, Hawaii	31	8	4.16†	......	Honomanu Valley, Maui.	17.14	3 stations	0.00
Idaho	25.5	− 1.7	Guffey	56	28	Chesterfield	−31	20	1.28	− 0.71	Salem	4.46	Buhl	0.06
Illinois	32.5	+ 2.3	Du Quoin	76	17	Lanark	− 6	8	1.10	− 1.15	Martinton	2.08	Bushnell	0.13
Indiana	34.1	+ 2.0	Marengo	71	17	Judyville	− 4	5, 8	1.59	− 1.26	Vevay	2.54	Judyville	1.02
Iowa	27.2	+ 3.6	Washington	67	14	Alton, Dows	−17	7	0.57	− 0.62	Ridgeway	2.07	Greenfield, Whitten	0.05
Kansas	35.9	+ 3.6	Independence; Oswego	74	16	St. Francis	− 7	2	0.16	− 0.73	Pleasanton	1.18	6 stations	0.00
Kentucky	39.8	− 1.9	Beattyville	74	17	Loretto, Farmers	7	3	2.42	− 1.33	Middlesboro	4.90	Eubank	0.67
Louisiana	55.6	+ 4.1	Monroe	89	17	Ferriday	20	23	3.22	− 1.14	Ruston	6.75	Southern Univ. Farm	0.70
Maryland and Delaware	36.1	+ 1.2	3 stations	71	1	Oakland, Md	1	23	3.32	− 0.03	Milford, Del	5.49	Chewsville, Md	1.25
Michigan	25.3	+ 0.5	Charlotte	61	1	Ewen	−14	22	2.06	− 0.13	Gladwin	5.37	Iron Mountain	0.73
Minnesota	17.5	+ 1.4	New Ulm	57	12	Detroit	−27	7	0.79	+ 0.04	Grand Meadow	1.45	Angus	0.23
Mississippi	50.9	+ 3.5	Leakesville	83	18	3 stations	20	2, 9	4.56	− 0.22	Louisville	8.81	Laurel	1.18
Missouri	38.4	+ 4.3	Belle	80	17	Unionville	− 4	7, 8	0.85	− 1.55	Clinton	1.82	Gallatin, Linneus	0.00
Montana	24.6	+ 0.5	Wolf Creek	70	13	Bowen	−27	17	0.52	− 0.16	Snowshoe	6.35	Choteau	0.00
Nebraska	29.1	+ 1.4	Franklin, Kearney	70	26	Lynch	−24	7	0.31	− 0.28	Valentine	1.38	15 stations	0.00
Nevada	28.0	− 2.8	Logan	67	24	Halleck	−20	13	0.19	− 0.86	Lewers' Ranch	1.00	6 stations	0.00
New England‡	26.2	− 0.4	Westboro, Mass	68	1	Van Buren, Me	−39	30	3.15	− 0.38	Bar Harbor, Me	5.95	Van Buren, Me	1.00
New Jersey	34.0	+ 0.8	Indian Mills	72	1	Vineland	1	24	3.63	− 0.22	Atlantic City	5.26	Sussex	2.10
New Mexico	36.5	+ 0.6	Carlsbad	84	15	Elizabethtown; Tres Piedras	−12; −12	1; 18	0.27	− 0.45	Frisco	2.62	9 stations	0.00
New York	26.4	+ 0.6	Athens	67	1	Old Forge	−27	10	2.42	− 0.87	Cutchogue	4.97	Hemlock Lake	0.54
North Carolina	45.3	+ 3.5	Whiteville	84	7	Banners Elk	8	3	4.26	+ 0.43	Horse Cove	8.92	Southport	2.07
North Dakota	14.4	+ 1.4	Lisbon	62	29	Pratt	−37	6	0.38	− 0.15	Jamestown	1.57	Buford	0.00
Ohio	33.1	+ 2.4	Pomeroy	68	17	Rome; Wauseon	− 2; − 2	6; 10	2.33	− 0.45	Rittman	3.88	Ottawa	0.93
Oklahoma	43.2	+ 4.0	Okmulgee	86	15	Hurley	6	2	0.07	− 1.50	Vinita	0.54	16 stations	0.00
Oregon	34.7	− 2.6	Vale	72	2	Christmas Lake	−20	18	3.70	− 2.70	Glenora	18.79	Ella	0.19
Pennsylvania	32.0	+ 1.3	Hanover	74	1	Lawrenceville; Saegerstown	− 2; − 2	23; 6	2.86	− 0.49	Johnstown	4.61	Pocono Lake	1.26
Porto Rico	74.5	......	Yauco	97	5	3 stations	53	3 d't's	4.51	......	Corozal	12.54	Sabana Grande	0.00
South Carolina	50.6	+ 5.0	Waterboro	83	1	Bowman	23	9	2.84	− 0.94	Clemson College	5.90	Charleston	0.94
South Dakota	21.8	+ 0.6	Ottumwa	65	13	Pollock	−23	7	0.77	+ 0.24	Milbank	2.55	Castlewood	0.16
Tennessee	43.5	+ 3.3	Dover	75	16	Mount'n City, Rugby	9	3	4.17	− 0.45	Tracy City	9.93	Dyersburg	1.45
Texas	52.1	+ 2.8	Waxahachie	93	17	Plemons	8	19	1.15	− 0.71	San Marcos	5.13	27 stations	0.00
Utah	25.4	− 1.7	Milford	66	11	Theodore; Wellington	−29; −29	20; 19	0.97	− 0.16	Grayson	6.20	Lucin, Ibapah	T.
Virginia	39.0	+ 1.4	3 stations	75	1, 18	Burkes Garden	5	3	3.86	+ 0.69	Speers Ferry	8.10	Stephens City	1.35
Washington	33.2	− 2.1	South Bend	65	2	Northport, Republic	− 5	17	4.15	− 1.36	Quiniault	21.35	Ephrata	0.20
West Virginia	36.4	+ 2.1	Williamson	73	17	Arbovale, Central Station.	3	3	3.03	− 0.64	Princeton	7.36	Harpers Ferry	1.06
Wisconsin	20.8	+ 0.1	Richland Center	59	30	Solon Springs	−19	7	1.28	− 0.17	Sturgeon Bay	4.37	Solon Springs	0.20
Wyoming	22.5	− 1.0	Phillips	62	15	Fontenelle	−34	18	0.87	− 0.08	Moorcroft	2.60	Eden	T

*53 stations; average elevation, 722 feet. †Average of 146 stations. ‡Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, and Connecticut.

DESCRIPTION OF TABLES AND CHARTS.

By Mr. P. C. DAY, Assistant Chief, Climatological Division.

For description of tables and charts see page 8 of REVIEW for January, 1908.

TABLE I.—*Climatological data for U. S. Weather Bureau stations, December, 1908.*

Stations.	Elevation of instruments. Barometer above sea level, feet.	Thermometers above ground.	Anemometer above ground.	Pressure, in inches. Actual, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hrs.	Departure from normal.	Temperature of the air, in degrees Fahrenheit. Mean max. + mean min. ÷ 2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.	Mean wet thermometer.	Mean temperature of the dew-point.	Mean relative humidity, per cent.	Precipitation, in inches. Total.	Departure from normal.	Days with .01, or more.	Wind. Total movement, miles.	Prevailing direction.	Maximum velocity. Miles per hour.	Direction.	Date.	Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness during daylight, tenths.	Total snowfall.
New England.							29.6	0.0										72	3.36	+ 0.1										6.5	
Eastport	76	67	85	29.85	29.94	— .04	24.2	— 0.1	52	1	33	— 1	11	16	41	22	18	78	5.01	+ 1.0	18	9,123	w.	60	se.	7	0	11	20	8.5	16.1
Greenville	1,070	6	....	28.75	29.97	......	13.9	......	53	1	24	—20	23	3	39	....	....	....	2.59	......	13	......	....	....	....	....	....	....	....	....	
Portland, Me.	103	81	117	29.88	30.00	— .03	26.4	— 0.7	63	1	34	3	23	19	30	23	16	67	2.92	— 0.8	11	7,434	w.	56	se.	7	11	9	11	5.2	13.5
Concord	288	70	79	29.69	30.02	— .04	24.8	— 1.6	61	1	34	— 6	24	16	26	....	....	....	2.27	— 1.1	8	4,008	nw.	28	w.	7	17	6	8	4.4	13.7
Burlington	404	12	47	29.54	30.00	— .05	21.4	— 4.1	56	1	30	— 4	23	13	37	....	....	....	1.59	— 0.1	18	10,103	s.	44	s.	4	2	8	21	8.5	14.1
Northfield	876	16	70	29.02	30.01	— .04	19.4	— 1.1	61	1	29	—12	11	9	36	17	15	83	2.62	— 0.1	18	5,988	n.	34	sw.	7	3	11	17	7.5	23.1
Boston	125	115	188	29.88	30.02	— .03	33.3	+ 1.7	67	1	41	10	6	26	28	29	24	70	2.47	— 0.9	17	8,457	w.	47	se.	7	10	8	13	5.9	3.5
Nantucket	12	14	90	30.00	30.01	— .04	37.0	+ 0.3	58	1	43	20	11	31	25	34	29	75	4.89	+ 1.2	13	12,558	w.	60	ne.	23	5	11	15	7.2	3.0
Block Island	26	11	46	30.00	30.02	— .04	36.5	— 0.1	59	1	42	19	10	31	25	33	27	69	4.62	+ 0.8	11	15,558	sw.	57	w.	7	7	7	17	6.5	3.6
Narragansett	....	9	....	....	....	....	33.7	+ 1.2	64	1	43	11	6	25	34	....	....	....	4.70	......	10	......	sw.	....	....	....	16	5	10	....	0.7
Providence	160	57	67	29.86	30.04	— .02	32.8	+ 1.2	66	1	41	12	6	25	28	29	23	70	3.12	— 0.3	8	5,870	w.	34	se.	7	12	9	10	5.2	2.1
Hartford	159	122	140	29.86	30.05	— .02	31.6	+ 1.8	65	1	38	13	24	25	30	27	22	69	3.36	— 0.2	8	5,906	nw.	39	w.	7	6	8	17	7.1	9.6
New Haven	106	116	155	29.92	30.04	— .03	33.4	+ 1.6	67	1	41	14	24	26	27	29	23	68	4.07	+ 0.4	11	7,044	w.	37	se.	7	11	9	11	5.2	7.3
Mid. Atlantic States.							35.9	+ 1.2										73	3.02	— 0.1										6.3	
Albany	97	102	115	29.93	30.04	— .04	28.6	+ 1.1	62	1	36	8	6	21	30	25	20	72	1.58	— 1.0	10	6,054	s.	30	s.	4	6	11	14	6.3	8.7
Binghamton	871	78	90	29.06	30.02	— .07	28.5	+ 0.8	61	1	35	5	6	22	34	....	....	....	1.47	— 1.0	12	5,417	w.	31	se.	30	2	7	22	8.1	9.7
New York	314	108	350	29.71	30.06	— .03	35.2	+ 0.8	64	1	41	20	10	30	24	32	26	69	3.21	— 0.2	10	10,712	w.	50	nw.	18	7	9	15	6.2	5.1
Harrisburg	374	94	104	29.68	30.10	— .02	33.7	+ 0.9	62	1	40	20	6	28	27	29	24	69	2.07	— 0.6	12	5,314	w.	36	w.	18	8	11	12	5.7	9.1
Philadelphia	117	116	184	29.97	30.10	— .01	37.1	+ 1.4	68	1	43	23	6	31	23	34	30	77	3.12	+ 0.1	10	7,629	nw.	35	nw.	23	10	9	12	5.8	6.0
Scranton	805	111	119	29.17	30.06	— .04	30.8	+ 1.0	60	1	37	14	6	24	28	27	20	64	2.17	— 0.4	13	5,762	sw.	32	w.	7	4	6	21	7.8	18.1
Atlantic City	52	37	48	30.03	30.09	— .01	37.6	+ 1.2	68	1	45	20	3	30	26	34	29	72	5.26	+ 1.5	13	6,136	nw.	38	ne.	23	8	5	18	6.6	5.3
Cape May	17	48	52	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	
Baltimore	123	100	113	29.97	30.11	— .02	37.9	+ 1.0	69	1	45	23	3	31	24	33	27	68	3.04	0.0	9	4,957	sw.	26	nw.	2	11	5	15	6.1	7.5
Washington	112	59	76	29.98	30.10	— .03	37.0	+ 0.9	69	1	45	18	24	29	28	32	26	69	3.63	+ 0.5	10	4,773	nw.	38	nw.	12	9	7	15	5.9	11.5
Cape Henry	18	9	58	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	
Lynchburg	681	83	88	29.36	30.13	— .01	40.0	+ 1.7	72	18	49	20	24	31	38	35	31	74	3.54	+ 0.3	9	3,042	nw.	24	nw.	12	7	10	14	6.4	10.9
Mount Weather	1,725	10	54	28.19	30.08	— .05	33.2	+ 1.7	63	1	41	14	3	26	31	29	24	74	1.68	— 1.4	9	12,530	nw.	60	nw.	26	8	9	14	6.4	10.2
Norfolk	91	102	111	30.01	30.11	— .02	45.4	+ 2.4	74	18	53	30	3	38	30	11	37	76	2.98	— 0.5	16	6,518	n.	39	n.	23	8	11	12	5.6	T.
Richmond	144	145	153	29.96	30.12	— .02	41.2	+ 0.2	70	18	50	20	24	33	33	....	....	....	4.72	+ 1.7	12	5,470	s.	33	sw.	1	12	5	14	5.6	17.2
Wytheville	2,293	40	47	27.68	30.13	— .02	36.8	+ 1.5	62	17	44	15	3	30	27	34	32	88	3.88	+ 0.1	13	4,558	w.	25	sw.	27	9	7	15	6.2	8.8
S. Atlantic States.							51.1	+ 4.0										78	2.65	— 1.0										5.4	
Asheville	2,255	53	75	27.72	30.15	— .01	41.3	+ 3.5	70	17	50	19	3	33	39	37	34	82	3.59	— 0.5	11	6,391	nw.	33	nw.	12	11	8	12	5.5	0.3
Charlotte	773	68	76	29.28	30.13	— .03	45.9	+ 3.0	72	18	54	26	3	38	25	41	37	76	4.06	+ 0.2	9	4,912	ne.	30	sw.	18	9	9	13	5.9	0.1
Hatteras	11	12	47	30.09	30.10	— .03	51.5	+ 2.7	74	1	58	37	11	45	27	48	46	86	4.54	— 0.6	11	11,431	n.	61	w.	25	15	8	8	4.9	
Manteo	....	....	....	....	....	....	48.6	......	75	1	58	29	9	39	....	....	....	....	3.46	— 1.7	8	......	n.	....	....	....	13	7	11	....	
Raleigh	376	71	79	29.71	30.12	— .03	45.6	+ 2.9	75	18	54	26	3	37	30	39	33	69	3.64	+ 0.5	13	5,659	sw.	38	nw.	25	11	8	12	5.7	T.
Wilmington	78	81	91	30.04	30.13	— .02	51.6	+ 4.4	77	1	61	30	24	42	31	45	41	76	2.22	— 0.9	11	5,572	sw.	32	sw.	11	11	14	6	4.7	
Charleston	48	14	92	30.08	30.13	— .02	55.8	+ 4.5	78	1	64	38	9	48	22	49	46	79	0.94	— 2.2	7	7,340	sw.	33	sw.	12	9	11	11	5.5	
Columbia, S. C.	351	41	57	29.74	30.13	— .03	50.6	+ 3.4	77	1	60	30	9	42	33	45	40	75	2.40	— 0.5	8	5,107	sw.	30	w.	25	5	16	10	5.9	
Augusta	180	89	97	29.94	30.13	— .03	51.6	+ 4.6	76	1	61	31	9	42	33	45	41	74	2.33	— 1.1	7	4,313	nw.	28	nw.	25	8	11	12	5.9	
Savannah	65	81	89	30.07	30.14	— .01	56.2	+ 4.9	79	1	65	35	9	48	26	50	45	75	1.09	— 2.0	7	5,030	w.	27	nw.	7	10	12	9	5.3	
Jacksonville	43	101	129	30.08	30.14	.00	60.8	+ 5.6	80	1	69	39	9	52	25	56	54	86	0.90	— 2.1	5	6,027	sw.	38	w.	25	12	10	9	4.8	
Florida Peninsula.							68.9	+ 3.6										82	0.68	— 1.4										4.4	
Jupiter	28	10	48	30.07	30.10	.00	69.7	+ 3.4	83	7	76	48	27	63	24	64	61	79	1.38	— 1.5	7	6,977	se.	26	ne.	23	6	23	2	5.1	
Key West	22	10	53	30.06	30.08	.00	72.5	+ 2.4	84	7	77	59	27	68	14	67	66	84	0.70	— 1.1	6	5,965	ne.	30	w.	12	13	16	2	4.1	
Sand Key	25	41	71	30.04	30.08	.00	73.1	......	82	8	76	62	27	71	9	....	....	....	0.24	— 1.6	3	11,069	ne.	36	nw.	13	15	16	0	4.0	
Tampa	35	79	96	30.09	30.13	+ .01	64.6	+ 5.1	81	1	74	41	27	55	29	58	55	82	0.39	— 1.6	3	5,073	ne.	23	w.	25	13	12	6	4.4	
East Gulf States.							53.7	+ 4.6										76	3.27	— 1.2										5.8	
Atlanta	1,174	190	216	28.88	30.14	— .02	48.0	+ 3.4	73	18	56	30	8	40	26	43	38	73	4.15	— 0.4	8	9,949	nw.	50	nw.	25	9	10	12	6.0	
Macon	370	78	87	29.74	30.14	— .02	51.6	+ 4.8	77	1	62	32	27	42	29	....	....	....	2.27	— 2.1	6	4,439	nw.	30	nw.	25	9	9	13	5.9	
Thomasville	273	8	58	29.85	30.15	.00	57.4	+ 4.9	82	1	69	29	27	46	36	50	47	82	1.04	— 2.6	8	4,040	nw.	24	sw.	25	12	11	8	4.6	
Pensacola	56	79	96	30.07	30.13	— .02	58.4	+ 4.5	74	1	66	36	23	50	24	....	....	....	2.31	— 1.9	7	6,877	n.	29	sw.	6	10	10	11	5.6	
Anniston	741	9	58	29.36	30.17	+ .01	49.4	+ 5.2	76	18	59	24	3	40	30	....	....	....	5.60	+ 1.1	8	4,874	nw.	30	nw.	25	11	0	20	6.8	
Birmingham	700	11	48	29.39	30.17	+ .01	49.8	+ 2.5	76	18	58	25	3	42	29	44	39	73	6.83	+ 2.2	7	5,624	n.	30	se.	6	9	8	14	6.0	
Mobile	57	98	106	30.07	30.13	— .02	57.8	+ 6.3	80	1	66	36	23	49	24	53	50	82	2.47	— 2.1	7	5,520	nw.	24	n.	31	6	17	8	6.0	
Montgomery	223	100	112	29.90	30.16	.00	53.8	+ 4.7	77	18	63	31	9	44	28	47	42	70	3.02	— 1.5	7	5,247	n.	26	nw.	25	9	10	12	5.9	
Meridian	375	84	93	29.75	30.15	— .01	51.6	+ 4.7	75	17	61	27	9	42	31	47	43	78	2.48	— 2.7	7	4,387	n.	27	nw.	25	8	11	12	6.2	
Vicksburg	247	62	74	29.88	30.16	+ .01	53.4	+ 4.0	77	18	62	32	3	45	31	47	40	68	3.98	— 1.0	10	5,311	e.	29	nw.	25	9	9	13	5.8	
New Orleans	51	88	121	30.08	30.14	+ .01	59.8	+ 5.4	83	1	68	38	3	52	25	54	51	79	1.79	— 2.7	5	6,396	n.	28	nw.	25	8	16	7	5.2	
West Gulf States.							51.9	+ 3.5										74	1.59	— 1.3										5.4	
Shreveport	249	77	84	29.88	30.16	+ .03	51.8	+ 2.9	78	17	60	32	3	43	29	46	41	72	2.13	— 2.2	9	5,255	se.	25	ne.	1	12	7	12	5.4	
Bentonville	1,303	11	44	28.72	30.12	— .01	41.3	+ 3.8	71	16	52	17	2	30	32	....	....	....	0.45	— 2.3	4	4,884	s.	24	s.	23	16	5	10	5.1	
Fort Smith	457	79	94	29.64	30.13	.00	45.6	+ 3.9	75	16	56	24	8	36	34	40	34	70	0.09	— 2.8	1	6,117	e.	32	nw.	25	13	6	12	5.4	
Little Rock	357	139	147	29.76	30.15	+ .01	47.5	+ 4.0	73	17	56	25	2	39	29	42	36	67	0.84	— 3.4	9	6,770	s.	40	w.	25	12	7	12	5.0	0.2
Brownsville	57	4	...	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	
Corpus Christi	20	69	77	30.10	30.12	.00	60.3	+ 3.7	81	6	67	40	22	54	25	55	53	82	1.97	+ 0.6	7	7,649	n.	47	e.	9	6	10	15	6.5	
Fort Worth	670	106	114	29.42	30.14	+ .02	50.8	+ 3.3	83	16	61	25	2	41	39	....	....	....	0.03	— 1.2	3	7,265	s.	32	nw.	18	16	7	8	4.5	
Galveston	54	106	112	30.09	30.15	+ .03	59.2	+ 2.9	73	17	64	40	22	54	22	56	54	85	2.74	— 1.0	9	8,458	n.	32	nw.	21	10	12	9	5.4	
Palestine	510	73	79	29.60	30.14	+ .02	52.6	+ 3.3	80	17	61	31	22	44	30	47	43	76	1.75	— 1.9	8	5,922	ne.	26	n.	25	5	15	11	6.5	
San Antonio	701	80	91	29.38	30.12	+ .01	56.6	+ 3.5	85	14	66	33	22	48	31	49	44	68	1.61	0.0	7	5,288	n.	33	n.	25	11	8	12	5.6	
Taylor	583	55	63	29.52	30.13	+ .02	53.6	+ 3.6	82	14	63	30	22	44	38	....	....	....	4.25	+ 1.6	8	6,071	n.	32	s.	17	13	8	10	5.0	
Ohio Val. and Tenn.							39.3	+ 2.2										75	2.64	— 0.8										6.5	
Chattanooga	762	106	112	29.34	30.17	+ .01	46.2	+ 3.6	69	17	54	27	8	39	27	41	37	74	6.67	+ 2.3	13	4,933	nw.	36	nw.	25	9	4	18	6.7	
Knoxville	1,004	93	100	29.07	30.15	— .01	42.8	+ 3.1	68	17	50	24	3	36	26	39	34	76	5.65	+ 1.5	14	3,964	sw.	30	w.	25	7	7	17	6.8	T.
Memphis	399	76	97	29.74	30.17	+ .02	46.8	+ 3.3	72	17	54	25	3	40	28	43	38	75	2.67	— 1.7	11	6,595	sw.	42	nw.	25	8	4	19	6.6	T.
Nashville	546	79	91	29.57	30.16	+ .01	42.4	+ 3.1	68	17	52	20	3	36	30	41	37	76	2.10	— 1.7	9	4,568	sw.	34	w.	25	7	10	14	6.4	T.
Lexington	989	75	102	29.04	30.14	.00	37.8	+ 1.4	67	17	45	15	2	30	30	....	....	....	2.13	— 1.2	11	8,468	sw.	36	w.	11	8	3	20	6.8	0.5
Louisville	525	111	132	29.55	30.14	.00	40.5	+ 2.4	66	17	48	18	2	33	29	36	31	71	1.85	— 1.9	7	6,284	sw.	28	w.	25	9	8	14	5.9	T.
Evansville	431	72	82	29.65	30.13	.00	40.2	+ 3.8	67	17	48	17	2	33	26	....	....	....	1.50	— 2.3	6	5,914	s.	25	s.	24	8	15	8	5.4	T.
Indianapolis	822	154	164	29.19	30.10	— .02	34.5	+ 1.9	63	17	42	11	2	27	25	30	26	73	1.54	— 1.5	8	7,899	sw.	34	sw.	26	10	10	11	5.7	3.5
Cincinnati	628	152	160	29.42	30.12	— .01	37.9	+ 1.5	65	17	46	16	2	30	31	33	28	69	1.60	— 1.3	11	5,504	sw.	24	w.	25	10	5	16	6.1	T.
Columbus	824	173	224	29.19	30.10	— .02	34.3	+ 1.5	62	18	42	14	2	27	29	30	26	74	1.59	— 1.2	11	9,549	sw.	41	nw.	7	7	12	12	6.2	0.2
Pittsburg	842	336	352	29.15	30.08	— .03	34.8	+ 0.1	60	18	41	14	3	28	33	31	25	70	1.94	— 0.8	13	9,188	w.	46	w.	7	3	11	17	7.2	1.3
Parkersburg	638	77	84	29.41	30.12	— .02	36.8	+ 1.6	66	17	44	11	3	29	32	33	30	79	2.29	— 0.5	11	4,827	s.	28	nw.	7	6	5	20	7.8	1.4
Elkins	1,940	41	50	28.00	30.13	— .01	34.6	+ 2.1	64	1	44	8	3	26	34	31	28	83	2.83	— 0.6	16	3,662	w.	23	s.	6	9	3	19	7.1	9.3
Lower Lake Region.							29.2	— 0.1										77	2.00	— 0.9										7.7	
Buffalo	767	178	206	29.15	30.00	— .06	29.6	— 0.5	49	1	35	12	23	24	28	28	24	80	2.92	— 0.4	19	15,629	w.	61	sw.	1	3	10	18	7.4	17.1
Canton	448	10	71	29.49	29.99	......	18.9	— 3.8	53	1	29	20	10	9	40	....	....	....	2.12	— 1.5	21	9,322	sw.	65	w.	1	6	6	19	7.4	19.1
Oswego	335	76	91	29.62	30.00	— .06	28.1	— 1.1	54	1	35	7	6	21	28	26	24	82	2.32	— 1.3	19	10,476	s.	38	nw.	7	1	3	27	8.8	13.9
Rochester	523	81	102	29.43	30.02	— .04	29.4	+ 0.5	53	1	35	10	23	24	31	27	22	76	1.15	— 1.7	14	8,202	w.	40	w.	1	3	8	20	8.0	10.0
Syracuse	597	97	113	29.33	30.00	— .07	28.2	— 0.1	55	1	35	7	23	22	31	....	....	....	1.45	— 1.2	16	11,096	w.	48	w.	7	2	6	23	7.8	9.8
Erie	713	92	102	29.23	30.02	— .05	31.9	+ 0.2	52	1	37	16	8	27	28	29	24	78	2.30	— 0.8	14	10,643	w.	40	w.	7	2	5	24	8.5	10.4
Cleveland	762	190	201	29.20	30.05	— .04	32.2	+ 1.1	53	1	38	14	8	26	28	29	25	75	2.75	+ 0.2	16	13,218	sw.	48	w.	7	3	8	20	7.8	5.2
Sandusky	629	62	70	29.34	30.05	— .04	32.2	+ 1.1	52	1	38	13	8	26	30	....	....	....	1.77	— 0.6	10	7,337	w.	31	w.	7	3	14	14	6.8	3.9
Toledo	628	207	246	29.36	30.06	— .02	31.4	+ 0.9	51	15	38	9	8	25	26	28	24	73	1.80	— 0.5	9	12,620	sw.	44	w.	7	7	8	16	6.6	3.2
Detroit	730	218	258	29.22	30.04	— .03	29.8	+ 0.3	50	15	35	11	8	24	28	27	24	80	1.38	— 1.0	14	12,531	w.	46	w.	7	2	12	17	7.7	6.9

TABLE I.—*Climatological data for U. S. Weather Bureau stations, December, 1908*—Continued.

Stations.	Elevation of instruments: Barometer above sea level, feet.	Elevation of instruments: Thermometers above ground.	Elevation of instruments: Anemometer above ground.	Pressure, in inches: Actual, reduced to mean of 24 hours.	Pressure, in inches: Sea level, reduced to mean of 24 hrs.	Pressure, in inches: Departure from normal.	Temperature: Mean max. + mean min. ÷ 2.	Temperature: Departure from normal.	Temperature: Maximum.	Temperature: Date.	Temperature: Mean maximum.	Temperature: Minimum.	Temperature: Date.	Temperature: Mean minimum.	Temperature: Greatest daily range.	Mean wet thermometer.	Mean temperature of the dew-point.	Mean relative humidity, per cent.	Precipitation: Total.	Precipitation: Departure from normal.	Precipitation: Days with .01, or more.	Wind: Total movement, miles.	Wind: Prevailing direction.	Wind: Maximum velocity: Miles per hour.	Wind: Maximum velocity: Direction.	Wind: Maximum velocity: Date.	Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness during daylight, tenths.	Total snowfall.
Upper Lake Region.							24.2	− 0.1										80	1.52	− 0.6										7.7	
Alpena	609	13	92	29.27	29.96	− .06	24.3	− 0.5	43	1	31	6	22	18	32	23	22	90	1.39	− 0.8	14	9,027	w.	42	w.	1	1	8	22	8.5	16.0
Escanaba	612	40	82	29.28	29.98	− .05	21.0	− 0.6	38	29	28	− 4	31	14	25	19	15	76	0.88	− 0.8	10	7,643	w.	34	nw.	27	2	6	23	8.1	12.4
Grand Haven	632	54	92	29.30	30.01	− .04	29.5	− 0.6	45	29	35	12	10	24	28	27	24	78	2.10	− 0.4	15	11,958	w.	51	nw.	7	2	6	23	8.2	15.8
Grand Rapids	707	121	162	29.22	30.02	− .03	28.4	− 0.4	45	29	34	14	2	23	23	26	24	83	1.88	− 0.7	13	8,914	w.	45	w.	30	2	5	24	8.5	7.4
Houghton	668	66	74	29.18	29.94	− .08	21.0	+ 0.1	39	30	27	3	31	15	27	....	....	....	1.33	− 1.1	20	5,669	nw.	33	nw.	1	0	4	27	9.4	19.1
Marquette	734	77	116	29.13	29.96	− .06	22.0	− 0.9	37	29	28	− 1	31	16	22	20	15	76	1.82	− 0.7	18	8,252	w.	43	sw.	30	1	6	24	8.1	19.5
Port Huron	638	70	120	29.30	30.01	− .05	27.5	+ 0.1	47	1	34	12	2	21	30	25	21	78	1.56	− 0.6	11	9,575	sw.	42	w.	1	4	9	18	7.5	17.2
Sault Sainte Marie	614	40	61	29.23	29.96	− .04	21.4	+ 0.9	40	1	28	− 2	5	15	30	20	18	86	2.66	+ 0.3	21	7,515	se.	48	w.	1	0	1	30	9.6	26.6
Chicago	823	140	310	29.15	30.06	− .02	31.3	+ 2.0	53	29	38	10	8	25	26	28	24	75	1.18	− 0.9	7	12,064	w.	52	w.	30	9	6	16	6.3	2.7
Milwaukee	681	122	139	29.28	30.04	− .02	26.1	+ 0.1	46	29	33	4	31	19	28	25	21	80	1.50	− 0.4	7	8,455	w.	40	e.	17	12	9	10	5.1	8.7
Green Bay	617	49	86	29.30	29.98	− .06	21.4	+ 0.1	40	29	29	− 4	31	14	29	19	16	78	1.40	− 0.4	12	8,489	sw.	47	w.	1	5	6	20	7.4	13.5
Duluth	1,133	11	47	28.71	29.98	− .07	16.0	− 1.7	42	26	23	−15	31	9	30	14	12	85	0.48	− 0.7	7	9,718	w.	47	w.	30	8	9	14	6.1	6.8
North Dakota.							14.8	+ 2.9										88	0.24	− 0.4										5.4	
Moorhead	940	8	57	28.99	30.06	− .02	13.4	+ 2.7	40	26	22	−18	7	5	36	13	12	94	0.48	− 0.3	9	6,612	sw.	36	nw.	30	14	6	11	4.8	4.5
Bismarck	1,674	8	57	28.22	30.10	+ .02	16.2	+ 1.2	45	13	26	−15	6	7	38	15	12	83	0.08	− 0.5	2	7,848	nw.	60	nw.	30	5	17	9	5.6	1.3
Devils Lake	1,482	11	44	28.35	30.00	− .06	10.8	+ 2.8	38	13	20	−24	6	2	33	10	9	93	0.37	0.0	8	8,778	w.	44	nw.	30	9	11	11	5.5	4.8
Williston	1,875	14	56	27.96	30.02	− .04	18.6	+ 5.0	48	26	29	−23	31	8	31	16	14	83	0.01	− 0.6	1	7,769	sw.	48	nw.	29	10	9	12	5.5	0.1
Upper Miss. Valley.							29.6	+ 2.3										74	1.01	− 0.9										5.4	
Minneapolis	......	102	208	......	......	......	21.0	......	48	14	29	− 8	31	13	34	....	....	....	1.33	+ 0.4	5	9,480	w.	47	w.	30	11	10	10	5.1	13.5
St. Paul	837	171	179	29.08	30.02	− .06	20.5	+ 1.2	46	14	29	− 9	31	12	34	19	14	75	1.28	+ 0.2	5	8,672	nw.	44	nw.	30	10	14	7	5.1	13.1
La Crosse	714	10	49	29.23	30.04	− .04	22.6	− 0.2	46	29	31	− 2	31	14	34	....	....	....	1.11	− 0.2	5	4,487	s.	23	nw.	30	7	8	16	6.2	8.0
Madison	974	70	78	28.95	30.05	− .03	23.2	+ 0.5	45	29	30	− 1	7	16	30	21	17	77	0.76	− 1.0	5	8,118	w.	35	w.	30	9	7	15	6.0	7.8
Charles City	1,015	10	49	28.95	30.07	− .03	23.2	+ 4.2	48	14	32	−11	7	15	29	21	19	86	1.16	− 0.1	4	6,086	nw.	31	nw.	30	10	9	12	5.9	4.4
Davenport	606	71	79	29.40	30.09	− .01	28.7	+ 1.5	55	14	37	1	7	21	29	26	21	76	0.40	− 1.3	5	5,986	w.	28	nw.	30	11	6	14	5.5	3.0
Des Moines	861	84	101	29.14	30.07	− .04	29.6	+ 3.9	54	28	38	− 7	7	21	31	27	23	77	0.31	− 1.0	4	6,034	nw.	28	nw.	25	8	17	6	5.2	4.1
Dubuque	698	100	117	29.31	30.09	− .01	25.8	+ 1.3	51	29	34	1	7	18	28	24	20	77	0.63	− 1.1	6	4,970	nw.	25	nw.	30	11	6	14	5.8	4.9
Keokuk	614	64	77	29.41	30.12	.00	33.4	+ 4.0	60	14	42	3	7	25	33	28	23	71	0.58	− 1.3	4	5,628	sw.	30	w.	30	16	6	9	4.4	4.0
Cairo	356	87	93	29.76	30.16	+ .01	42.1	+ 3.6	70	17	50	19	2	34	31	37	31	67	1.54	− 1.8	6	7,234	s.	32	nw.	25	12	6	13	5.4	
La Salle	536	56	64	29.51	30.11	+ .02	29.0	+ 1.5	54	29	38	4	7	20	30	....	....	....	0.83	− 1.4	5	6,718	w.	31	w.	30	10	8	13	5.5	3.5
Peoria	609	11	45	29.42	30.11	.00	29.4	+ 1.3	53	29	38	6	7	21	30	27	23	77	0.82	− 1.6	6	6,407	nw.	31	w.	30	13	6	12	5.3	3.8
Springfield, Ill.	644	10	92	29.40	30.11	− .01	33.7	+ 2.4	64	17	42	12	2	26	30	30	24	71	1.62	− 0.8	4	6,094	nw.	28	sw.	26	14	5	12	5.0	3.0
Hannibal	534	75	109	29.52	30.11	− .01	34.4	+ 3.1	63	17	44	9	7	25	37	....	....	....	1.13	− 0.5	4	6,638	sw.	38	sw.	26	16	2	13	4.7	1.6
St. Louis	567	208	217	29.49	30.11	− .02	38.9	+ 3.4	72	17	47	14	2	30	31	34	27	65	1.64	− 1.6	4	7,998	nw.	38	nw.	25	13	4	14	5.2	0.1
Missouri Valley.							30.9	+ 4.0										73	0.63	− 0.4										4.5	
Columbia, Mo.	784	11	84	29.26	30.12	.00	36.2	+ 3.3	69	16	46	10	2	26	29	....	....	....	1.23	− 0.8	2	6,314	sw.	32	sw.	26	16	4	11	4.4	3.2
Kansas City	963	116	181	29.05	30.12	.00	37.4	+ 5.9	61	14	45	9	7	29	29	32	26	67	0.27	− 1.1	3	9,305	s.	45	nw.	25	15	7	9	4.3	T.
Springfield, Mo	1,324	98	104	28.69	30.13	.00	39.6	+ 4.1	69	16	49	14	2	30	30	34	29	71	0.67	− 2.0	5	7,829	s.	39	nw.	25	16	5	10	4.3	T.
Iola	984	11	50	29.07	30.15	+ .03	37.7	+ 5.2	68	16	48	14	7	28	34	....	....	....	0.59	− 0.3	4	5,267	sw.	29	sw.	26	12	9	10	5.1	T.
Topeka	......	85	89	......	......	......	36.2	+ 5.1	61	14	46	9	7	27	32	....	....	....	0.19	− 0.7	4	6,960	s.	34	nw	30	17	8	6	3.7	T.
Lincoln	1,189	11	84	28.80	30.11	− .01	31.7	+ 4.8	64	26	42	0	7	22	37	27	21	69	0.16	− 0.5	1	7,532	s.	42	nw.	24	14	10	7	4.5	1.0
Omaha	1,105	115	121	28.88	30.11	.00	31.8	+ 4.7	60	26	40	− 3	7	24	32	27	21	68	0.26	− 0.6	3	6,672	nw.	34	n.	4	13	8	10	4.8	2.7
Valentine	2,598	47	54	27.31	30.13	+ .03	24.5	0.0	49	13	36	−13	7	13	49	21	19	83	1.38	+ 0.8	5	6,915	w.	36	nw.	24	13	15	3	4.2	14.3
Sioux City	1,135	96	164	28.83	30.09	− .03	27.2	+ 4.6	51	14	35	−10	7	19	36	....	....	....	0.34	− 0.4	4	9,324	nw.	50	nw.	30	13	12	6	4.6	2.6
Pierre	1,572	70	75	28.39	30.12	+ .02	23.6	+ 3.5	53	13	32	−11	7	15	47	20	15	69	0.60	+ 0.1	5	6,267	w.	49	nw.	30	12	15	4	4.6	6.6
Huron	1,306	56	67	28.65	30.11	+ .01	19.4	+ 3.7	46	14	29	−15	7	10	43	18	15	84	1.00	+ 0.4	7	7,489	nw.	40	nw.	30	13	10	8	4.5	10.4
Yankton	1,233	49	57	28.72	30.09	− .02	25.0	+ 2.8	53	13	34	−14	7	15	46	....	....	....	0.87	+ 0.1	7	6,347	nw.	37	nw.	30	9	11	11	5.6	6.8
Northern Slope.							25.0	+ 1.3										76	0.52	− 0.3										5.5	
Havre	2,505	11	44	27.33	30.06	+ .01	22.6	+ 1.4	52	25	34	−15	31	11	38	20	17	80	0.27	− 0.4	3	8,075	sw.	48	w.	25	13	9	9	5.0	2.7
Miles City	2,371	26	48	27.49	30.14	+ .04	26.2	+ 5.2	56	28	36	− 5	31	16	32	21	17	76	0.25	− 0.4	5	4,252	s.	43	nw.	24	11	15	5	4.5	2.5
Helena	4,110	8	56	25.81	30.15	+ .02	25.7	+ 0.9	52	25	34	− 8	1	18	32	22	18	73	0.52	− 0.3	5	5,191	w.	45	w.	28	4	12	15	6.6	6.7
Kalispell	2,962	11	34	26.99	30.16	+ .09	25.2	+ 1.3	45	28	31	− 3	2	19	18	23	20	80	0.47	− 1.4	12	3,290	nw.	31	sw.	24	2	7	22	8.2	2.6
Rapid City	3,234	46	50	26.60	30.14	+ .05	28.2	+ 2.2	53	26	40	− 5	6	17	49	23	17	71	0.73	+ 0.3	7	4,751	w.	37	sw.	25	9	10	12	5.4	10.2
Cheyenne	6,088	56	64	23.96	30.11	+ .02	28.6	− 0.4	52	9	38	− 2	1	19	37	23	16	61	0.70	+ 0.4	5	8,859	w.	52	nw.	24	15	9	7	4.2	8.3
Lander	5,372	26	36	24.64	30.22	+ .07	19.1	− 0.1	50	26	31	−19	18	7	34	16	12	76	1.03	+ 0.3	3	1,966	sw.	30	nw.	24	8	18	5	5.1	10.3
Sheridan	3,790	9	47	26.09	30.15	......	21.6	......	59	25	35	−16	18	8	49	18	15	81	0.92	......	7	3,739	nw.	48	w.	25	9	10	12	5.4	12.4
Yellowstone Park	6,200	11	48	23.86	30.22	+ .06	20.0	− 1.6	38	3	28	− 9	1	12	29	17	14	79	0.48	− 1.3	9	6,310	s.	37	sw.	25	7	5	19	6.9	8.3
North Platte	2,821	11	51	27.12	30.17	+ .07	29.1	+ 2.5	55	26	42	− 4	7	17	40	23	19	80	0.20	− 0.3	5	5,261	w.	34	n.	24	15	9	7	4.0	2.9
Middle Slope.							35.0	+ 3.0										67	0.13	− 0.6										4.0	
Denver	5,291	129	136	24.72	30.13	+ .05	31.4	− 0.8	58	26	44	− 4	2	19	49	25	18	64	0.63	0.0	5	5,183	sw.	49	w.	24	15	11	5	4.0	9.7
Leadville	10,248	7																													
Pueblo	4,685	80	86	25.30	30.11	+ .03	32.2	+ 0.5	64	26	45	0	1	20	42	26	18	60	0.03	− 0.4	2	4,980	nw.	50	nw.	24	17	12	2	3.1	0.7
Concordia	1,398	42	50	28.62	30.14	+ .03	34.9	+ 5.4	62	26	45	6	7	25	32	29	25	75	0.01	− 0.5	1	4,555	sw.	25	nw.	25	11	14	6	4.0	T.
Dodge City	2,509	44	54	27.47	30.15	+ .05	36.2	+ 4.6	64	26	49	14	7	24	38	28	24	72	0.04	− 0.5	3	5,951	nw.	36	nw.	24	19	5	7	3.8	0.1
Wichita	1,358	90	120	28.68	30.16	+ .05	38.0	+ 3.8	64	26	48	11	7	28	33	32	25	64	0.03	− 0.8	1	7,591	s.	35	nw.	24	15	10	6	4.2	T.
Oklahoma	1,214	10	47	28.81	30.13	+ .02	42.8	+ 4.2	73	16	54	20	2	32	32	36	30	67	0.03	− 1.7	1	11,373	s.	48	nw.	24	11	15	5	4.6	
Southern Slope.							46.7	+ 3.0										62	0.06	− 0.9										5.2	
Abilene	1,738	45	54	28.30	30.14	+ .03	49.5	+ 4.5	83	16	60	23	2	39	38	41	33	61	0.00	− 1.1	0	5,506	s.	30	s.	3	4	16	11	6.3	
Amarillo	3,676	10	49	26.30	30.10	+ .01	41.2	+ 4.8	72	16	55	18	19	27	41	32	25	62	0.00	− 0.8	0	8,337	s.	36	w.	24	25	4	2	3.1	
Del Rio	944	8	57	29.12	30.12	+ .02	54.6	+ 2.2	88	14	66	26	22	43	44	....	....	....	0.00	− 1.3	0	5,032	nw.	31	nw.	18	7	13	11	6.1	
Roswell	3,578	9	57	26.44	30.15	+ .08	41.6	+ 0.4	76	16	57	14	19	26	49	33	25	63	0.01	− 0.5	1	4,150	nw.	31	nw.	12	9	15	7	5.3	
Southern Plateau.							41.3	− 0.8										61	1.78	+ 0.8										4.0	
El Paso	3,762	110	133	26.26	30.09	+ .06	46.6	+ 1.8	76	16	57	22	21	36	32	38	27	51	0.15	− 0.4	4	7,098	nw.	40	nw.	3	12	13	6	4.9	T.
Santa Fe	7,013	33	39	23.26	30.18	+ .12	30.6	+ 0.3	52	9	42	7	19	20	35	24	19	67	0.10	− 0.7	3	6,648	ne.	38	nw.	24	21	7	3	2.8	0.6
Flagstaff	6,907	8	57	23.35	30.11	+ .05	27.2	− 1.2	53	27	41	−14	18	14	43	22	19	77	5.74	+ 3.8	6	4,054	e.	42	sw.	16	13	6	12	5.0	11.6
Phoenix	1,108	50	56	28.88	30.06	+ .02	53.2	+ 1.3	75	2	64	31	18	42	32	45	36	58	1.94	+ 1.4	4	2,260	e.	20	sw.	16	12	15	4	4.2	
Yuma	141	9	58	29.93	30.08	+ .03	53.6	− 2.1	72	31	65	34	21	42	33	44	38	53	2.58	+ 2.1	5	4,781	n.	30	n.	19	20	7	4	2.8	
Brawley																															
Independence	3,910	11	42	26.06	30.13	+ .01	36.6	− 5.0	59	27	50	10	16	23	42	30	22	60	0.20	− 1.4	1	3,882	nw.	26	n.	18	16	10	5	4.3	1.0
Middle Plateau.							28.0	− 2.7										72	0.92	− 0.2										4.8	
Reno	4,532	56	63	25.52	30.19	+ .04	31.4	− 2.3	59	26	43	− 1	18	20	33	26	21	69	0.16	− 1.5	3	2,034	w.	22	w.	13	13	8	10	4.6	2.6
Tonopah	6,089	12	20	24.09	30.23	......	31.9	+ 1.8	51	25	38	7	18	26	20	27	19	62	0.08	− 0.7	2	5,646	se.	30	se.	2	15	8	8	4.1	1.4
Winnemucca	4,344	18	56	25.69	30.21	+ .03	29.3	− 1.4	55	26	44	− 5	19	15	42	22	19	73	0.03	− 1.0	1	3,903	ne.	26	s.	13	13	4	14	5.3	0.3
Modena	5,479	10	43	24.68	30.21	+ .09	24.6	− 7.1	52	8	38	−17	20	11	43	20	16	75	0.85	0.0	5	5,507	w.	34	sw.	9	10	12	9	5.2	8.4
Salt Lake City	4,366	105	110	25.70	30.18	+ .03	30.1	− 2.0	49	4	37	6	20	23	23	27	23	74	0.45	− 0.9	6	2,566	se.	38	nw.	24	5	14	12	6.0	6.2
Durango	6,546	18	56	23.69	30.23	+ .16	24.6	− 3.7	46	9	38	− 3	18	11	38	20	16	75	3.64	+ 2.2	6	3,625	nw.	24	ne.	24	15	8	8	4.0	17.1
Grand Junction	4,608	43	51	25.51	30.22	+ 0.2	23.8	− 4.4	44	16	34	− 6	20	14	33	20	17	79	1.21	+ 0.8	4	2,260	nw.	18	w.	17	17	5	9	4.3	9.0
Northern Plateau.							30.3	− 1.8										80	0.80	− 0.9										7.6	
Baker City	3,471	48	58	26.53	30.23	+ .07	26.1	− 1.3	45	28	34	0	18	19	25	24	21	81	0.37	− 1.2	7	4,008	se.	21	s.	28	6	10	15	6.4	5.5
Boise	2,739	78	86	27.31	30.26	+ .06	31.1	− 1.1	47	28	37	11	20	25	17	28	25	79	1.15	− 0.6	10	2,885	nw.	29	w.	23	4	5	22	8.0	0.9
Lewiston	757	10	51	29.38	30.21	+ .08	34.4	− 3.1	55	25	40	11	20	28	20	....	....	....	0.41	− 1.1	8	3,605	e.	43	w.	28	3	7	21	7.7	0.6
Pocatello	4,477	46	54	25.56	30.23	+ .04	26.9	− 1.5	47	4	34	−10	19	19	31	25	21	78	0.38	− 0.5	13	6,207	se.	38	sw.	24	4	11	16	7.2	3.7
Spokane	1,929	101	110	28.08	30.20	+ .12	29.0	− 1.8	47	12	34	13	17	24	15	27	24	80	1.56	− 1.1	9	4,582	sw.	35	sw.	25	2	6	23	8.2	9.4
Walla Walla	1,000	71	79	29.12	30.22	+ .10	34.2	− 1.8	61	25	39	15	18	30	20	31	28	82	0.96	− 1.1	10	3,703	s.	31	se.	25	4	6	21	8.0	0.7
N. Pac. Coast Reg.							40.1	− 1.5										87	5.67	− 2.2										7.5	
Blaine	57	4																													
North Head	211	11	56	29.84	30.07	+ .04	43.4	− 0.9	53	4	47	33	18	40	12	42	41	90	6.53	− 1.0	17	13,516	e.	74	s.	12	7	3	21	7.4	
Port Crescent	259	12	29	29.80	30.09	+ .11	38.6	+ 0.3	54	25	44	29	18	34	18	....	....	....	6.23	− 0.6	17	4,347	se.	36	sw.	25	1	11	19	7.2	

TABLE I.—*Climatological data for U. S. Weather Bureau stations, December, 1908*—Continued.

Stations.	Elevation of instruments.			Pressure, in inches.			Temperature of the air, in degrees Fahrenheit.									Mean wet thermometer.	Mean temperature of the dew-point.	Mean relative humidity, per cent.	Precipitation, in inches.			Wind.					Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness during daylight, tenths.	Total snowfall.
	Barometer above sea level, feet.	Thermometers above ground.	Anemometer above ground.	Actual, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hrs.	Departure from normal.	Mean max. + mean min. ÷ 2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.				Total.	Departure from normal.	Days with .01, or more.	Total movement, miles.	Prevailing direction.	Maximum velocity. Miles per hour.	Maximum velocity. Direction.	Maximum velocity. Date.					
N. P. Coast Reg—Cont.																															
Seattle	123	185	224	29.99	30.12	+ .11	39.5	− 1.7	52	8	44	26	20	36	13	38	36	88	3.61	− 2.4	15	6,859	se.	48	s.	25	4	7	20	7.6	
Tacoma	213	113	120	29.85	30.11	+ .10	38.0	− 2.3	53	25	43	24	20	34	16	38	37	93	6.00	− 1.3	16	4,249	sw.	30	sw.	24	1	7	23	8.5	
Tatoosh Island	86	7	57	29.93	30.03	+ .07	42.6	− 1.3	52	8	46	34	15	40	10	40	37	82	10.66	− 3.9	18	17,501	e.	90	sw.	25	7	11	13	6.7	T.
Portland, Oreg	153	68	106	29.98	30.14	+ .07	39.0	− 2.3	54	12	43	23	19	35	13	36	33	81	3.80	− 3.5	15	5,157	se.	31	sw.	25	5	8	18	7.3	0.7
Roseburg	510	9	57	29.58	30.14	+ .03	39.6	− 2.3	58	12	44	26	19	35	24	38	37	90	3.00	− 2.9	14	1,649	e.	17	sw.	23	1	10	20	8.1	
Mid. Pac. Coast Reg.							44.5	− 3.8										84	2.69	− 1.9										6.0	
Eureka	62	62	80	30.06	30.13	+ .01	47.0	− 1.0	61	25	53	30	18	40	22	44	41	81	3.91	− 3.3	14	3,586	se.	26	se.	8	6	12	13	6.3	
Mount Tamalpais	2,375	11	18	27.62	30.13	+ .01	43.0		59	25	47	31	19	39	21	41	40	91	3.87	− 0.4	13	12,992	se.	52	nw.	16	15	2	14	5.1	
Point Reyes Light	490	7	18	29.56	30.08		49.0		59	11	53	40	28	45	12				2.72		11	11,929	se.	71	nw.	16	12	2	17	5.7	
Red Bluff	332	50	56	29.80	30.17	+ .03	41.8	− 4.6	60	6	48	25	19	36	21	39	36	81	2.64	− 1.8	9	2,816	nw.	20	n.	16	6	5	20	7.0	1.5
Sacramento	69	106	117	30.09	30.17	+ .03	42.1	− 4.2	61	11	48	28	18	37	22	41	38	85	2.04	− 1.5	12	3,881	se.	21	sw.	4	6	7	18	7.1	
San Francisco	155	200	204	29.97	30.14	+ .02	47.0	− 3.9	61	10	52	35	20	43	14	44	41	81	2.15	− 2.1	11	3,758	ne.	22	sw.	4	11	10	10	5.3	
San Jose	141	78	88	29.98	30.14		44.6	− 5.3	64	3	53	25	18	36	30				1.54	− 2.7	8	3,274	se.	24	se.	4	8	9	14	5.8	
Southeast Farallon	30	9	17																												
S. Pac. Coast Reg.							50.3	− 2.3										70	1.00	− 1.2										5.3	
Fresno	330	67	70	29.80	30.18	+ .05	41.3	− 5.5	64	4	48	29	16	35	31	39	37	88	0.57	− 1.0	5	2,340	se.	16	s.	4	3	6	22	7.7	
Los Angeles	338	159	191	29.72	30.09	+ .02	55.2	− 0.1	76	29	64	38	18	46	30	46	38	58	1.46	− 1.4	3	4,536	ne.	24	sw.	16	12	8	11	4.9	
San Diego	87	94	102	29.98	30.08	+ .01	53.7	− 2.0	69	29	61	37	19	47	24	47	42	69	0.27	− 1.6	5	3,787	nw.	26	w.	16	18	2	11	4.1	
San Luis Obispo	201	47	54	29.90	30.13	+ .02	51.2	− 1.6	73	25	61	28	19	41	35	46	39	67	1.70	− 0.6	7	3,713	nw.	24	w.		14	8	9	4.4	
West Indies.																															
Grand Turk	11	6	20																												
San Juan	82	48	90	29.88	29.96	− .01	76.6		83	5	81	69	27	72	13	72	70	82	5.96	+ 1.7	27	8,807	e.	35	ne.	1	16	11	4	3.9	
Panama.																															
Christobal	17	5	60	29.84	29.86		77.8		84	4	82	69	15	74		75	74	88	9.07		22	7,156	ne.	28	ne.	25	6	17	8	6.0	
Bas Obispo	172	4	30	29.68	29.86		77.4		89	8	85	64	17	69		73	72	95	6.63		22	2,824	nw.	18	nw.	26	1	18	12	7.0	
Ancon	92	6	69	29.75	29.84		79.6		91	22	88	68	13	72		73	72	89	4.16		22	4,905	nw.	19	nw.	14	5	13	13	7.0	
Alhajuela																			4.02		22										
Bohio																			3.40		27										
Gatun																			7.95		24										

TABLE II.—*Accumulated amounts of precipitation for each 5 minutes, for storms in which the rate of fall equaled or exceeded 0.25 in any 5 minutes, or 0.80 inch in 1 hour, during December, 1908, at all stations furnished with self-registering gages.*

Stations.	Date.	Total duration. From—	Total duration. To—	Total amount of precipitation.	Excessive rate. Began—	Excessive rate. Ended—	Amount before excessive began.	5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
Abilene, Tex. †																					
Albany, N. Y	7			0.83														*			
Alpena, Mich	17–18			0.50														*			
Amarillo, Tex. †																					
Anniston, Ala	6–7	7:52 p. m.	D. N.	1.81	7:56 p. m.	8:12 p. m.	0.01	0.07	0.35	0.43											
Asheville, N. C	6			0.90														0.21			
Atlanta, Ga	6			0.64														0.24			
Atlantic City, N. J	6–7	9:10 p. m.	3:05 p. m.	2.03	6:59 a. m.	7:13 a. m.	0.96	0.07	0.19	0.37											
Augusta, Ga	2			0.38														0.36			
Baker City, Oreg	11–12			0.13														*			
Baltimore, Md	7			0.72														0.43			
Bentonville, Ark	6			0.12														0.10			
Binghamton, N. Y	7			0.34														0.06			
Birmingham, Ala	6	5:40 p. m.	10:15 p. m.	2.85	7:34 p. m.	9:34 p. m.	0.63	0.05	0.12	0.23	0.31	0.33	0.55	0.70	0.81	0.86	0.91	1.00	1.30	1.71	2.14
Bismarck, N. Dak	15–16			0.08														*			
Block Island, R. I	30			0.99														0.41			
Boise, Idaho	23			0.32														0.10			
Boston, Mass	7			1.10														0.32			
Buffalo, N. Y	7			0.52														0.16			
Burlington, Vt	7			0.79														*			
Cairo, Ill	6			0.43														0.21			
Canton, N. Y	7			0.58														*			
Charles City, Iowa	16–17			0.76														*			
Charleston, S. C	12			0.48														0.29			
Charlotte, N. C	22			2.27														0.40			
Chattanooga, Tenn	6			3.05														0.48			
Cheyenne, Wyo	16–17			0.53														*			
Chicago, Ill	16–17			0.65														*			
Cincinnati, Ohio	18			0.29														0.25			
Cleveland, Ohio	17–18			0.99														0.14			
Columbia, Mo	29			0.91														0.22			
Columbia, S. C	22			1.11														0.36			
Columbus, Ohio	30			0.35														0.10			
Concord, N. H	7			1.45														0.34			
Concordia, Kans	4			0.01														0.01			
Corpus Christi, Tex	18	12:56 p. m.	9:00 p. m.	0.70	1:36 p. m.	2:06 p. m.	0.05	0.14	0.24	0.36	0.39	0.49	0.54								
Davenport, Iowa	5–6			0.24														*			
Del Rio, Tex	27			0.10														0.10			
Denver, Colo	17			0.28														*			
Des Moines, Iowa	5–6			0.29														*			
Detroit, Mich	29			0.18														0.13			
Devils Lake, N. Dak	29–30			0.20														*			
Dodge City, Kans	4			0.02														*			
Dubuque, Iowa	5–6			0.39														*			
Duluth, Minn	17			0.24														*			
Durango, Colo	15–16			1.47														*			
Eastport, Me	7			0.82														0.15			
Elkins, W. Va	30			0.35														0.13			
El Paso, Tex	3			0.08														0.07			
Erie, Pa	17–18			1.04														*			
Escanaba, Mich	17–18			0.36														*			
Eureka, Cal	4			0.73														0.35			
Evansville, Ind	18			0.34														0.16			
Flagstaff, Ariz	15–16			2.60														*			

TABLE II.—*Accumulated amounts of precipitation for each 5 minutes, etc.*—Continued.

Stations.	Date.	Total duration.		Total amount of precipitation.	Excessive rate.		Amount before excessive began.	Depths of precipitation (in inches) during periods of time indicated.													
		From—	To—		Began—	Ended—		5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
Fort Smith, Ark	29			0.09														0.04			
Fort Worth, Tex	28			0.01														0.01			
Fresno, Cal	2			0.26														0.02			
Galveston, Tex	9–10			1.27														*			
Grand Haven, Mich	16–17			0.66														*			
Grand Junction, Colo	15–16			0.63														*			
Grand Rapids, Mich	29			0.24														0.13			
Green Bay, Wis	16–17			0.61														*			
Greenville, Me	7			1.15														*			
Hannibal, Mo	29			0.66														0.25			
Harrisburg, Pa	30			0.21														0.08			
Hartford, Conn	7			1.99														*			
Hatteras, N. C	4–5	7:35 p. m.	3:15 a. m.	2.55	10:32 p. m.	11:51 p. m.	0.58	0.08	0.30	0.14	0.52	0.60	0.66	0.74	0.79	0.87	0.97	1.10	1.43		
Havre, Mont	4–5			0.24														*			
Helena, Mont	30–31			0.21														*			
Houghton, Mich	20			0.15														*			
Huron, S. Dak	16–17			0.82														*			
Independence, Cal	2			0.20														0.07			
Indianapolis, Ind	6			0.47														*			
Iola, Kans	3			0.30														0.23			
Jacksonville, Fla	12			0.54														0.51			
Jupiter, Fla	31	8:29 a. m.	10:50 a. m.	0.83	9:51 a. m.	10:26 a. m.	0.01	0.13	0.30	0.38	0.51	0.63	0.72	0.80							
Kalispell, Mont	22–23			0.12														*			
Kansas City, Mo	4			0.17														0.06			
Keokuk, Iowa	29			0.28														*			
Key West, Fla	22			0.62														0.30			
Knoxville, Tenn	1			0.44														0.39			
La Crosse, Wis	16–17			0.73														*			
Lander, Wyo	16–17			0.98														*			
La Salle, Ill	29			0.31														0.11			
Lewiston, Idaho	4			0.07														0.04‡			
Lexington, Ky	30			0.63														0.20			
Lincoln, Nebr	5			0.16														*			
Little Rock, Ark	6			0.34														0.12			
Los Angeles, Cal	2–3			1.36														0.31			
Louisville, Ky	18			0.33														0.21			
Lynchburg, Va	7			0.80														0.23			
Macon, Ga	22			0.98														0.40			
Madison, Wis	16–17			0.46														*			
Marquette, Mich	17–18			0.53														*			
Memphis, Tenn	29			0.37														0.33			
Meridian, Miss	6			0.74														0.31			
Milwaukee, Wis	6			0.83														0.10			
Minneapolis, Minn	16–17			1.10														*			
Mobile, Ala	29			1.03														0.36			
Modena, Utah	16–17			0.52														*			
Montgomery, Ala	21			2.11														0.52			
Moorhead, Minn	30			0.14														*			
Mount Tamalpais, Cal	9			1.06														0.32			
Mount Weather, Va	22–23			0.97														*			
Nantucket, Mass	7			1.55														0.73			
Nashville, Tenn	18			0.33														0.32			
New Haven, Conn	7			1.96														0.37			
New Orleans, La	29			1.36														0.40			
New York, N. Y	7			1.81														0.36			
Norfolk, Va	4			0.40														0.24			
Northfield, Vt	7			1.56														*			
North Head, Wash	24			0.79														0.42			
North Platte, Nebr	5–6			0.10														*			
Oklahoma, Okla	29			0.03														0.02			
Omaha, Nebr	5			0.23														0.06			
Oswego, N. Y	7			0.47														*			
Palestine, Tex	20			0.63														0.19			
Parkersburg, W. Va	11			0.74														0.19			
Pensacola, Fla	30			0.67														0.51			
Peoria, Ill	29			0.38														*			
Philadelphia, Pa	7			1.34														0.07			
Phoenix, Ariz	3			0.69														0.19			
Pierre, S. Dak	16–17			0.44														*			
Pittsburg, Pa	6–7			0.61														*			
Pocatello, Idaho	16–17			0.15														*			
Point Reyes Light, Cal	4			0.83														0.33			
Port Huron, Mich	17			0.72														*			
Portland, Me	7			1.13														0.18			
Portland, Oreg	25			0.73														0.14			
Providence, R. I	7			1.58														0.27			
Pueblo, Colo	17			0.02														*			
Raleigh, N. C	22			2.34														0.33			
Rapid City, S. Dak	16–17			0.33														*			
Red Bluff, Cal	4			1.35														0.26			
Reno, Nev	16			0.08														*			
Richmond, Va	7			0.90														0.24			
Rochester, N. Y	17–18			0.27														*			
Roseburg, Oreg	23			0.76														0.22			
Roswell, N. Mex	23			0.01														0.01			
Sacramento, Cal	9			0.24														0.16			
St. Louis, Mo	29			0.50														0.10			
St. Paul, Minn	16–17			1.00														*			
Salt Lake City, Utah	16–17			0.34														*			
San Antonio, Tex	9			1.30														0.49			
San Diego, Cal	16			0.10														0.10			
Sand Key, Fla	22			0.18														0.18			
Sandusky, Ohio	17			0.58														*			
San Francisco, Cal	4			0.96														0.34			
San Jose, Cal	4			0.33														0.21			
San Luis Obispo, Cal	2			0.51														0.22			
Santa Fe, N. Mex	3			0.05														*			
Sault Sainte Marie, Mich	1–2			0.80														*			
Savannah, Ga	17			0.78														0.26			
Scranton, Pa	7			0.67														0.06			
Seattle, Wash	27			0.56														0.16			
Sheridan, Wyo	16–17			0.50														*			
Shreveport, La	6			0.87														0.24			
Sioux City, Iowa	16–17			0.19														*			

TABLE II.—*Accumulated amounts of precipitation for each 5 minutes, etc.*—Continued.

Stations.	Date.	Total duration. From—	Total duration. To—	Total amount of precipitation.	Excessive rate. Began—	Excessive rate. Ended—	Amount before excessive began.	5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
Southeast Farallon, Cal.	4			0.85														0.41			
Spokane, Wash	22-23			0.57														*			
Springfield, Ill	29			1.32														*			
Springfield, Mo	6			0.29														*			
Syracuse, N. Y	6-7			0.26														*			
Tacoma, Wash	24			0.86														0.16			
Tampa, Fla	12			0.25														0.21			
Tatoosh Island, Wash	12			1.14														0.28			
Taylor, Tex	28	5:05 a. m.	9:45 a. m.	2.25	7:06 a. m.	8:51 a. m.	0.23	0.15	0.29	0.48	0.67	0.89	1.01	1.04	1.05	1.10	1.18	1.32	1.63	1.83	
Thomasville, Ga	22			0.26														0.15			
Toledo, Ohio	6			0.37														0.13			
Tonopah, Nev	2,16			0.04														*			
Topeka, Kans	4			0.07														0.05			
Valentine, Nebr	16,17			0.81														*			
Vicksburg, Miss	6	3:50 p. m.	8:25 p. m.	1.00	4:00 p. m.	4:11 p. m.	0.05	0.16	0.45	0.51											
Walla Walla, Wash	12			0.46														0.10			
Washington, D. C	7			0.75														0.39			
Wichita, Kans	3			0.03														0.03			
Williston, N. Dak	11			0.01														0.01			
Wilmington, N. C	12			0.66														0.44			
Winnemucca, Nev	23			0.03														*			
Wytheville, Va	22			1.32														*			
Yankton, S. Dak	16-17			0.61														*			
Yellowstone Park, Wyo.	28			0.11														*			
Honolulu, T. H	19			0.67														0.25			
San Juan, P. R	16-17	11:28 p. m.	D. N.	0.52	11:30 p. m.	11:50 p. m.	0.01	0.05	0.14	0.28	0.46										

* Partly estimated. † No precipitation occurred during month. ‡ Estimated.

RAINFALL IN JAMAICA.

Thru the kindness of Mr. Maxwell Hall, meteorologist to the government of Jamaica and now in charge of the meteorological service of that island, we have received the following data:

Comparative table of rainfall.

[Based upon the average stations only.]

OCTOBER, 1908.

Divisions.	Relative area.	Number of stations.	Rainfall. 1908.	Rainfall. Average.
	Per cent.		*Inches.*	*Inches.*
Northeastern division	25	17	11.54	15.02
Northern division	22	41	11.89	7.76
West-central division	26	20	11.90	13.30
Southern division	27	26	8.88	12.04
Means	100		11.05	12.03

The rainfall over the island for October was therefore an inch below the average.

The greatest rainfall recorded was 25.35 inches, at Bath, and the smallest recorded was 3.17 inches, at Pedro Plains.

On the 31st flood-rains threatened the estates in St. James, on the northern shore, as much as 4 inches falling in less than 2 hours.

At Georgetown, Grand Cayman, 14.16 inches fell on 21 days; the greatest fall was 2.39 on the 20th.

NOVEMBER, 1908.

Divisions.	Relative area.	Number of stations.	Rainfall. 1908.	Rainfall. Average.
Northeastern division	25	17	10.81	9.39
Northern division	22	41	5.71	5.65
West-central division	26	20	5.29	5.85
Southern division	27	26	4.29	4.71
Means	100		6.52	6.40

The rainfall over the island for November was therefore the average. The greatest rainfall recorded was 25.05 inches, at Fellowship, and the smallest recorded was 0.79 inches, at Belleisle.

At Georgetown, Grand Cayman, 3.58 inches fell on 10 days; the greatest daily fall was 1.48 inch on the 17th.

DECEMBER, 1908.

Divisions.	Relative area.	Number of stations.	Rainfall. 1908.	Rainfall. Average.
Northeastern division	25	17	13.52	9.78
Northern division	22	41	4.97	2.82
West-central division	26	20	4.44	3.81
Southern division	27	26	5.10	2.82
Means	100		7.01	4.81

The rainfall over the island for December was therefore 2 inches above the average.

The greatest rainfall recorded was 45.69 inches, at Fellowship, and the smallest recorded was 1.47 inches, at Whithorn.

At Georgetown, Grand Cayman, 2.74 inches fell on 5 days; the greatest fall was 2.50 inches on the 31st.

TABLE III.—*Data furnished by the Canadian Meteorological Service, December, 1908.*

Stations.	Pressure. Actual, reduced to mean of 24 hours.	Pressure. Sea level, reduced to mean of 24 hours.	Pressure. Departure from normal.	Temperature. Mean.	Temperature. Departure from normal.	Temperature. Mean maximum.	Temperature. Mean minimum.	Precipitation. Total.	Precipitation. Departure from normal.	Precipitation. Total snowfall.
	Ins.	Ins.	Ins.	°	°	°	°	Ins.	Ins.	Ins.
St. Johns, N. F	29.63	29.77	—.06	27.7	— 1.0	34.0	21.3	6.46	+1.43	20.3
Sydney, C. B. I	29.85	29.89	.00	27.2	— 1.0	34.4	20.1	7.45	+2.82	17.4
Halifax, N. S	29.85	29.96	.00	25.7	— 1.9	32.6	18.8	7.76	+2.64	8.0
Grand Manan, N. B	29.88	29.93	—.05	28.0	— 0.3	36.8	19.2	4.72	+0.30	10.5
Yarmouth, N. S	29.89	29.96	—.02	30.4	— 0.3	37.6	23.2	6.29	+1.25	11.3
Charlottetown, P. E. I	29.86	29.90	—.04	22.6	— 1.7	30.2	15.0	4.43	+0.77	16.1
Chatham, N. B	29.88	29.91	—.03	14.2	— 2.8	23.1	5.4	3.02	—0.20	23.6
Father Point, Que	29.89	29.92	—.03	13.0	— 2.4	20.7	5.3	3.66	+0.83	36.6
Quebec, Que	29.62	29.96	—.05	12.4	— 2.8	19.9	5.0	4.22	+0.53	37.7
Montreal, Que	......	......	......	......	......	......	......	......	......	......
Rockliffe, Ont	29.34	29.98	—.03	11.0	— 4.0	21.1	0.9	2.98	+0.49	22.4
Ottawa, Ont	29.73	30.07	+.05	14.9	— 2.1	23.8	6.0	3.93	+1.02	38.6
Kingston, Ont	29.68	30.01	—.03	23.9	+ 0.2	32.1	15.6	2.16	—1.08	13.2
Toronto, Ont	29.60	30.00	—.05	29.1	+ 2.1	35.2	23.0	2.04	—0.87	16.5
White River, Ont	......	......	......	......	......	......	......	......	......	......
Port Stanley, Ont	29.37	30.03	—.04	28.7	+ 0.3	35.3	22.2	2.83	+0.41	11.4
Southampton, Ont	29.22	......	......	27.9	+ 1.2	34.0	21.7	3.83	—0.15	37.4

Stations.	Pressure. Actual, reduced to mean of 24 hours.	Pressure. Sea level, reduced to mean of 24 hours.	Pressure. Departure from normal.	Temperature. Mean.	Temperature. Departure from normal.	Temperature. Mean maximum.	Temperature. Mean minimum.	Precipitation. Total.	Precipitation. Departure from normal.	Precipitation. Total snowfall.
	Ins.	Ins.	Ins.	°	°	°	°	Ins.	Ins.	Ins.
Parry Sound, Ont	29.24	29.97	—.04	21.1	— 0.1	29.5	12.6	5.30	+0.82	53.0
Port Arthur, Ont	29.22	29.96	—.03	14.4	+ 1.2	23.7	5.2	2.73	+1.86	27.3
Winnipeg, Man	29.13	30.00	—.02	10.0	+ 5.9	17.9	2.0	0.65	—0.26	6.5
Minnedosa, Man	28.06	29.96	—.06	10.0	+ 4.3	18.7	1.2	0.28	—0.34	2.8
Qu' Appelle, Assin	27.60	29.95	—.05	11.4	+ 4.0	20.0	2.7	0.68	+0.16	....
Medicine Hat, Alberta	27.66	30.02	+.05	21.8	+ 3.6	32.5	11.1	0.12	—0.43	1.2
Swift Current, Sask	27.35	30.04	+.05	17.1	+ 1.1	25.6	8.6	0.16	—0.62	....
Calgary, Alberta	26.32	29.99	+.05	21.2	+ 3.0	32.9	9.5	0.20	—0.39	2.0
Banff, Alberta	25.28	30.08	+.14	16.1	— 3.0	23.4	8.9	1.71	+0.50	17.1
Edmonton, Alberta	......	......	......	......	......	......	......	......	......	....
Prince Albert, Sask	......	......	......	......	......	......	......	......	......	....
Battleford, Sask	28.14	29.97	—.02	6.2	+ 0.8	14.7	— 2.4	0.04	—0.28	....
Kamloops, B. C	28.78	30.04	+.10	24.6	— 4.3	31.1	19.0	0.90	+0.12	....
Victoria, B. C	29.97	30.07	+.10	39.8	— 1.4	43.3	36.3	4.88	—3.10	....
Barkerville, B. C	25.54	29.95	+.07	19.8	— 1.1	27.8	11.7	2.95	—0.22	....
Hamilton, Bermuda	30.00	30.16	+.04	66.4	+ 1.7	71.3	61.4	1.36	—3.13	....
Dawson, Yukon	......	......	......	......	......	......	......	......	......	....

TABLE IV.—*Heights of rivers referred to zeros of gages, December, 1908.*

Stations.	Distance to mouth of river.	Flood stage on gage.	Highest water. Height.	Highest water. Date.	Lowest water. Height.	Lowest water. Date.	Mean stage.	Monthly range.
	Miles.	Feet.	Feet.		Feet.		Feet.	Feet.
Republican River.								
Clay Center, Kans	42	18	6.7	16	6.1	4-8	6.3	0.6
Smoky Hill-Kansas River.								
Abilene, Kans	254	22	0.9	2,5	0.4	27,28,31	0.6	0.5
Manhattan, Kans	160	18	3.1	1,2	2.5	8	2.9	0.6
Topeka, Kans	87	21	6.3	1	5.7	10	5.9	0.6
Missouri River.								
Bismarck, N. Dak	1,309	14	4.8	29,30	1.8	1	3.2	3.0
Pierre, S. Dak	1,114	14	2.2	31	— 0.5	1	0.9	2.7
Sioux City, Iowa	784	17	8.4	4	5.2	12	6.3	3.2
Blair, Nebr	705	15	5.3	27	3.6	4	4.2	1.7
St. Joseph, Mo	481	10	2.9	1	— 1.7	13	—0.4	4.6
Kansas City, Mo	388	21	9.6	1	4.5	14,15	5.6	5.1
Glasgow, Mo	231	21	10.3	3	6.3	21	7.7	4.0
Boonville, Mo	199	20	11.1	3	6.8	17-19	7.8	4.3
Hermann, Mo	103	24	12.5	4	5.0	29,30	7.5	7.5
Minnesota River.								
Mankato, Minn	127	18	3.3	1	2.5	29-31	2.8	0.8
St. Croix River.								
Stillwater, Minn. (a)	23	11	......	......	......	......	......	......
Illinois River.								
La Salle, Ill	197	18	13.2	9	12.1	14,15	12.4	1.1
Peoria, Ill	135	14	8.7	1,2,5,6, 22,23, 28-31	8.4	11-13,15	8.6	0.3
Conemaugh River.								
Johnstown, Pa	64	7	2.8	19	0.3	3,4	0.9	2.5
Allegheny River.								
Warren, Pa	177	14	1.1	19-21	— 0.7	9-11	0.1	1.8
Parker, Pa	73	20	3.4	19	0.0	10	0.9	3.4
Freeport, Pa	29	20	6.5	19,20	0.7	3,4,7,8	2.2	5.8
Springdale, Pa	17	27	11.6	20	7.6	4-10	8.4	4.0
Youghiogheny River.								
Confluence, Pa. (b)	59	10	......	......	......	......	......	......
West Newton, Pa	15	23	1.6	19	— 0.1	3,4	0.4	1.7
Monongahela River.								
Fairmont, W. Va	119	25	14.3	20	10.0	11	12.4	4.3
Greensboro, Pa	81	18	7.5	19,20	5.8	2,9	6.5	1.7
Lock No. 4, Pa	40	28	10.0	20	8.9	1-4	9.3	1.1
Muskingum River.								
Zanesville, Ohio	70	25	8.0	21-31	7.7	1-7	7.8	0.3
Little Kanawha River.								
Creston, W. Va	38	20	2.5	15-17	— 1.8	1-5	0.6	4.3
New-Great Kanawha River.								
Hinton, W. Va	153	14	5.5	31	2.0	1-3	3.1	3.5
Charleston, W. Va	58	30	8.6	10,13,14	5.9	30	7.3	2.7
Scioto River.								
Columbus, Ohio	110	17	1.6	1-31	1.6	1-31	1.6	0.0
Licking River.								
Falmouth, Ky	30	25	2.4	30	1.0	1-5,28	1.6	1.4
Kentucky River.								
Beattyville, Ky	254	30	3.5	25	0.3	3,4	1.4	3.2
Frankfort, Ky	65	31	7.7	26	5.6	1-3	6.4	2.1
Wabash River.								
Terre Haute, Ind	171	16	0.3	1-8	0.2	9-31	0.2	0.1
Mount Carmel, Ill	75	15	1.7	2-4	1.4	18-31	1.5	0.3
Cumberland River.								
Burnside, Ky	518	50	7.8	25	— 0.1	1,2	2.9	7.9
Celina, Tenn	383	45	8.9	27	1.2	2-5	4.0	7.7
Carthage, Tenn	308	40	6.8	28	1.1	4	3.7	5.7
Nashville, Tenn	193	40	11.7	28,29	7.5	4,6	9.6	4.2
Clarksville, Tenn	126	43	9.2	31	2.5	7	6.5	6.7
Clinch River.								
Speers Ferry, Va	156	20	4.6	8	1.1	1	2.4	3.5
Clinton, Tenn	52	25	12.0	25	4.6	1	7.9	7.4
South Fork Holston River.								
Bluff City, Tenn	35	12	5.9	8	1.6	6,21	2.6	4.3
Holston River.								
Rogersville, Tenn	103	14	7.3	8	2.6	21	3.8	4.7

Stations.	Distance to mouth of river.	Flood stage on gage.	Highest water. Height.	Highest water. Date.	Lowest water. Height.	Lowest water. Date.	Mean stage.	Monthly range.
	Miles.	Feet.	Feet.		Feet.		Feet.	Feet.
French Broad River.								
Asheville, N. C	144	4	2.5	8	0.0	1,2,4-6	0.6	2.5
Dandridge, Tenn	46	12	7.7	8	1.3	1	2.8	6.4
Tennessee River.								
Knoxville, Tenn	635	12	11.1	9	1.4	1	4.4	9.7
Loudon, Tenn	590	25	9.5	8	1.6	1	4.6	7.9
Kingston, Tenn	556	25	8.7	9	2.3	1	5.2	6.4
Chattanooga, Tenn	452	33	14.0	9	2.3	1	7.5	11.7
Bridgeport, Ala	402	24	11.0	10	1.1	1	5.8	9.9
Guntersville, Ala	349	31	16.8	10	2.6	3	9.8	14.2
Florence, Ala	255	16	9.7	11	0.5	2,3	5.3	9.2
Riverton, Ala	225	32	21.4	12	8.7	2,3	15.2	12.7
Johnsonville, Tenn	95	21	13.3	13	2.0	6	7.9	11.3
Ohio River.								
Pittsburg, Pa	966	22	6.9	20	3.8	8	6.0	3.1
Coraopolis, Pa	956	25	9.9	16	5.1	22	9.3	4.8
Beaver Dam, Pa	937	27	8.1	21	1.5	9-11	3.3	6.6
Wheeling, W. Va	875	36	7.1	21	0.8	2-7,11-13	2.5	6.3
Parkersburg, W. Va	785	36	7.7	22,23	0.6	1	2.6	7.1
Point Pleasant, W. Va	703	39	6.4	23	1.2	2,3	3.4	5.2
Huntington, W. Va	660	50	10.5	28	3.6	3	6.6	6.9
Catlettsburg, Ky	651	50	11.0	28	2.3	3	5.4	8.7
Portsmouth, Ohio	612	50	10.7	29	2.7	4,5	5.9	8.0
Maysville, Ky	559	50	11.0	29	3.0	3	5.9	8.0
Cincinnati, Ohio	499	50	12.2	30	4.0	3-6	5.2	8.2
Madison, Ind	413	46	10.4	31	3.4	7,8	5.7	7.0
Louisville, Ky	367	28	5.6	31	2.2	4	3.3	3.4
Evansville, Ind	184	35	6.5	31	2.4	12,14,15	3.6	4.1
Mount Vernon, Ind	148	35	5.4	31	2.0	14	3.2	3.4
Paducah, Ky	47	40	8.8	30,31	2.2	6-8	5.4	6.6
Cairo, Ill	1	45	14.1	14	7.7	1	11.2	6.4
Neosho River.								
Iola, Kans	262	10	6.3	1	— 1.2	29-31	0.0	7.5
Oswego, Kans	184	20	21.7	1	0.8	26-31	4.0	20.9
Fort Gibson, Okla	3	22	31.0	1	10.5	27-30	15.0	20.5
Canadian River.								
Calvin, Okla	99	15	6.1	1	3.2	14,31	3.7	2.9
Black River.								
Blackrock, Ark	67	12	7.0	1	2.3	30,31	3.2	4.7
White River.								
Calicorock, Ark	272	18	6.2	3	0.0	31	1.6	6.2
Batesville, Ark	217	18	7.9	1-3	2.0	31	3.6	5.9
Clarendon, Ark	75	30	21.7	8,9	10.5	31	16.3	11.2
Arkansas River.								
Wichita, Kans	832	10	0.2	2	— 0.7	28-31	—0.4	0.9
Tulsa, Okla	551	16	15.0	1	3.1	28-31	5.2	11.9
Webbers Falls, Okla	465	23	26.5	1	7.4	31	12.9	19.1
Fort Smith, Ark	403	22	29.0	2	6.7	29	13.5	22.3
Dardanelle, Ark	256	21	25.3	3	6.1	31	13.9	19.2
Little Rock, Ark	176	23	24.8	4	5.5	31	13.6	19.3
Yazoo River.								
Greenwood, Miss	175	38	9.7	9	1.9	2,3	5.5	7.8
Yazoo City, Miss	80	25	7.4	12	— 1.0	1	3.9	8.4
Ouachita River.								
Camden, Ark	304	39	13.3	3	5.2	20,21	7.3	8.1
Monroe, La	122	40	13.2	10-12	1.9	1	9.0	11.3
Red River								
Arthur City, Tex	688	27	19.5	2	7.5	29	10.5	12.0
Fulton, Ark	515	28	23.8	5,6	10.2	29	14.8	13.6
Shreveport, La	327	29	12.0	7	0.7	1	5.3	11.3
Alexandria, La	118	36	17.5	10,11	3.6	1,2	9.4	13.9
Mississippi River.								
Fort Ripley, Minn. (c)	2,082	10	......	......	......	......	......	......
St. Paul, Minn. (a)	1,954	14	......	......	......	......	......	......
Red Wing, Minn. (a)	1,914	14	......	......	......	......	......	......
Reeds Landing, Minn	1,884	12	0.6	16	0.0	24-29,31	0.2	0.6
La Crosse, Wis. (d)	1,819	12	......	......	......	......	......	......

TABLE IV.—*Heights of rivers referred to zeros of gages*—Continued.

Stations.	Distance to mouth of river.	Flood stage on gage.	Highest water. Height.	Highest water. Date.	Lowest water. Height.	Lowest water. Date.	Mean stage.	Monthly range.
Mississippi River.—Cont'd.	*Miles.*	*Feet.*	*Feet.*		*Feet.*		*Feet.*	*Feet.*
Prairie du Chien, Wis (a)	1,759	18	....	....	....	....	....	....
Dubuque, Iowa	1,699	18	3.6	22,23	1.2	7	2.8	2.4
Leclaire, Iowa (f)	1,609	10	....	....	....	....	....	....
Davenport, Iowa	1,593	15	2.6	1,2	0.8	9	1.8	1.8
Muscatine, Iowa	1,562	16	3.7	27	1.5	10	2.6	2.2
Galland, Iowa	1,472	8	1.4	1,2	0.5	11	1.0	0.9
Keokuk, Iowa	1,463	15	2.2	1,2	− 0.5	8	1.0	2.7
Warsaw, Ill	1,458	18	5.0	1,2	2.9	13	4.1	2.1
Hannibal, Mo	1,402	13	3.2	1–3	0.8	13,14	2.0	2.4
Grafton, Ill	1,306	23	5.2	2–5	3.0	16	4.2	2.2
St. Louis, Mo	1,264	30	11.5	5	3.0	24,25	5.9	8.5
Chester, Ill	1,189	30	9.9	6	3.6	26	5.9	6.3
Cape Girardeau, Mo	1,128	28	13.9	7	6.1	26	9.0	7.8
New Madrid, Mo	1,003	34	11.4	14,15	6.0	1	9.0	5.4
Memphis, Tenn	843	33	9.5	16,17	5.3	1,2	7.4	4.2
Helena, Ark	767	42	10.8	17,18	5.7	1–3	8.2	5.1
Arkansas City, Ark	635	42	22.2	11,12	9.3	31	15.8	12.9
Greenville, Miss	595	42	17.9	12	6.9	1	12.4	11.0
Vicksburg, Miss	474	45	19.3	13,14	5.6	1	12.9	13.7
Natchez, Miss	373	46	20.3	15	7.4	1	14.8	12.9
Baton Rouge, La	240	35	13.2	16	4.0	1,2	9.1	9.2
Donaldsonville, La	188	28	8.8	15,16	3.0	4	6.1	5.8
New Orleans, La	108	18	5.9	14,15	3.3	4	4.7	2.6
Atchafalaya River.								
Simmesport, La	127	41	18.4	15,16	3.5	1	12.5	14.9
Melville, La	103	37	21.2	16	7.4	1	15.8	13.8
Morgan City, La	19	8	4.5	11,12	3.4	3,23	4.0	1.1
Hudson River.								
Troy, N. Y	154	14	4.0	20	1.5	26,27	2.2	2.5
Albany, N. Y	147	12	3.7	11	0.3	3	2.0	3.4
Delaware River.								
Hancock (E. Branch), N. Y	287	12	4.2	8	2.9	3	3.4	1.3
Hancock (W. Branch), N. Y	287	10	4.7	15	2.6	4	3.9	2.1
Port Jervis, N. Y	215	14	3.0	12	1.6	4–6	2.2	1.4
Phillipsburg, N. J	146	26	1.6	11,17	0.5	6,7	1.1	1.1
Trenton, N. J	92	18	1.4	8,9	0.9	7,21–29	1.0	0.5
North Branch Susquehanna.								
Binghamton, N. Y	183	14	2.5	23	1.8	6	2.1	0.7
Wilkes-Barre, Pa	60	17	2.8	26	2.1	10	2.5	0.7
West Branch Susquehanna.								
Williamsport, Pa	39	20	2.7	21	0.4	2–8	0.8	2.3
Susquehanna River.								
Harrisburg, Pa	69	17	1.8	23	0.3	9	1.0	1.5
Shenandoah River.								
Riverton, Va	58	22	− 0.6	1	− 0.9	8–25	−0.8	0.3
Potomac River.								
Cumberland, Md	290	8	3.8	19,20	1.8	1–11	2.7	2.0
Harpers Ferry, W. Va	172	18	0.2	20,21	− 0.4	10–12	−0.1	0.6
James River.								
Lynchburg, Va	260	20	4.3	31	1.1	3–6	1.8	3.2
Columbia, Va	167	18	8.9	31	5.8	6,21,22	6.6	3.1
Richmond, Va	111	10	1.7	31	0.3	6	1.0	1.4
Dan River.								
Danville, Va	55	8	4.6	23	0.3	4,18–22	0.9	4.3
Roanoke River.								
Clarksville, Va	196	12	6.2	23	0.6	1	2.2	5.6
Weldon, N. C	129	30	31.5	24	10.8	3–6	15.7	20.7
Tar River.								
Greenville, N. C	21	22	13.5	30	4.4	2–4	7.0	9.1
Haw River.								
Moncure, N. C	171	25	23.2	23	7.3	2–3	9.2	15.9
Cape Fear River.								
Fayetteville, N. C	112	38	38.2	24	4.5	7,21	10.7	33.7
Pedee River.								
Cheraw, S. C	149	27	31.8	24	3.0	2,7,8	8.2	28.8
Smiths Mills, S. C	51	16	13.6	31	5.6	5	8.1	8.0
Lynch Creek.								
Effingham, S. C	35	12	4.6	14,15,28,29	3.5	7,8,21,22	4.0	1.1
Black River.								
Kingstree, S. C	45	12	3.3	26,27	2.0	5,14,15	2.7	1.3
Catawba-Wateree River.								
Mount Holly, N. C	143	15	5.0	23	1.8	1,11–21	2.2	3.2
Catawba, S. C	107	11	13.1	23	2.3	5	4.2	10.8
Camden, S. C	37	24	29.2	24	6.8	20	10.8	22.4
Congaree River.	*Miles.*	*Feet.*	*Feet.*		*Feet.*		*Feet.*	*Feet.*
Columbia, S. C	52	15	15.9	24	1.6	7,8,20,21	3.5	14.3
Santee River.								
Ferguson, S. C	82	12	13.8	30	8.3	9	10.6	5.5
Savannah River.								
Calhoun Falls, S. C	347	15	9.0	23	2.8	5,6	3.8	6.2
Augusta, Ga	268	32	26.0	23	7.8	1	11.0	18.2
Oconee River.								
Dublin, Ga	79	30	11.8	28	0.9	2,3,9	3.5	10.9
Ocmulgee River.								
Macon, Ga	134	18	16.9	23	2.3	1	4.7	14.6
Abbeville, Ga	51	11	11.0	31	2.5	3,4	4.3	8.5
Flint River.								
Montezuma, Ga	152	20	12.0	27	3.0	1	5.3	9.0
Albany, Ga	99	20	7.4	30,31	1.0	2,3	2.6	6.4
Bainbridge, Ga	22	22	9.5	31	4.9	1–4	5.9	4.6
Chattahoochee River.								
Oakdale, Ga	305	18	11.0	23	3.0	1	5.4	8.0
West Point, Ga	174	20	11.7	23	2.2	1	4.3	9.5
Eufaula, Ala	90	40	20.0	25	1.6	1	6.1	18.4
Alaga, Ala	30	25	17.0	25	3.0	1	6.5	14.0
Coosa River.								
Rome, Ga	266	30	18.7	8	1.0	1,5,6	4.6	17.7
Gadsden, Ala	162	22	17.5	9	1.0	1	6.5	16.5
Lock No. 4, Ala	113	17	13.5	10	0.3	1	5.2	13.2
Wetumpka, Ala	12	45	19.4	11	1.6	1	8.6	17.8
Alabama River.								
Montgomery, Ala	323	35	15.3	11	0.3	1	6.1	15.0
Selma, Ala	246	35	16.7	12	− 0.2	1	6.7	16.9
Black Warrior River.								
Tuscaloosa, Ala	90	43	40.5	8	5.0	1	14.5	35.5
Tombigbee River.								
Columbus, Miss	316	33	7.5	23	− 3.0	1	1.9	10.5
Demopolis, Ala	168	35	25.0	27	− 1.2	1	11.0	26.2
Pascagoula River.								
Merrill, Miss	78	20	2.4	11,12	1.0	1,3	1.8	1.4
Pearl River.								
Columbia, Miss	110	18	5.2	31	3.0	1–3	4.2	2.2
Sabine River.								
Logansport, La	315	25	7.5	25	3.1	19,20	5.2	4.4
Neches River.								
Beaumont, Tex	18	10	1.5	1	0.3	22	0.9	1.2
Trinity River.								
Dallas, Tex	320	25	20.3	1	4.9	30	7.0	15.4
Long Lake, Tex	211	35	10.4	8	3.0	1	6.1	7.4
Liberty, Tex	20	25	10.2	12	5.3	9	6.6	4.9
Brazos River.								
Waco, Tex	285	24	5.2	5	1.5	23–27	2.4	3.7
Hempstead, Tex	140	40	1.7	1	− 0.2	8	0.7	1.9
Booth, Tex	61	39	4.9	1	4.4	24–31	4.6	0.5
Colorado River.								
Austin, Tex	214	18	3.0	5	1.4	1,26–28	1.7	1.6
Columbus, Tex	98	24	7.8	9	6.2	3,29–31	6.7	1.6
Red River of the North.								
Moorhead, Minn (a)	284	26	....	....	....	....	....	....
Snake River.								
Lewiston, Idaho	144	24	2.0	6,12	0.9	20	1.6	1.1
Riparia, Wash	67	30	2.7	2,7	1.5	24	2.4	1.2
Columbia River.								
Wenatchee, Wash	473	40	6.5	1,2	6.2	8–10	6.3	0.3
Umatilla, Oreg	270	25	2.9	1,2	1.3	31	2.1	1.6
The Dalles, Oreg	166	40	3.4	1	0.5	23	1.9	2.9
Willamette River.								
Albany, Oreg	118	20	8.8	30	2.0	11,12,22	3.5	6.8
Portland, Oreg	12	15	5.4	29,30	1.5	18,19	3.1	3.9
Sacramento River.								
Red Bluff, Cal	265	23	3.9	5	1.0	21–23	1.6	2.9
Colusa, Cal	156	28	6.2	7	3.4	24	4.1	2.8
Knights Landing, Cal	99	18	5.0	7,8	2.1	22,23	2.9	2.9
Sacramento, Cal	64	25	9.6	7	6.8	21–23	7.5	2.8
San Joaquin River.								
Pollasky, Cal	203	10	0.0	1–31	0.0	1–31	0.0	0.0
Firebaugh, Cal	148	14	− 0.4	18,19,25–27	− 1.3	1–15	−0.9	0.9
Lathrop, Cal	49	14	1.2	11	0.3	1	0.7	0.9

(a) River frozen during month. (b) River frozen for 22 days. (c) River frozen for 26 days. (d) River frozen for 25 days. (e) River frozen for 29 days. (f) River frozen for 24 days.

Honolulu, T. H., latitude 21° 19′ north, longitude 157° 52′ west; barometer above sea, 38 feet; gravity correction, —0.057 inch, applied. December, 1908.

Day.	Pressure, in inches.*		Air temperature, degrees Fahrenheit.				Moisture.				Wind, in miles per hour.				Precipitation, inches.		Clouds.					
							8 a. m.		8 p. m.		8 a. m.		8 p. m.				8 a. m.			8 p. m.		
	8 a. m.	8 p. m.	8 a. m.	8 p. m.	Maximum.	Minimum.	Wet.	Relative humidity.	Wet.	Relative humidity.	Direction.	Velocity.	Direction.	Velocity.	8 a. m.	8 p. m.	Amount.	Kind.	Direction, from.	Amount.	Kind.	Direction, from.
							°	%	°	%												
1	29.97	29.96	74.0	72.0	78	70	67.0	69	66.0	73	ne.	7	e.	5	0.00	T.	8 Few	A.-cu. Cu.	s. 0	2 5	A.-cu. Cu.	nw. ne.
2	29.97	29.97	74.7	73.0	79	71	65.6	61	67.0	73	e.	7	ne.	4	0.00	0.00	5	A.-cu.	e.	8	Cu.	ne.
3	29.97	29.96	75.0	72.1	78	70	67.0	66	67.0	77	ne.	3	ne.	9	0.01	0.00	5	A.-cu.	e.	3	Cu.	ne.
4	30.00	29.99	73.0	72.5	78	70	65.5	67	66.0	71	ne.	12	ne.	10	T.	0.00	3	Cu.	e.	2	Cu.	ne.
5	30.02	30.01	74.3	72.5	79	69	67.0	68	66.0	71	ne.	8	e.	3	0.00	0.00	3 1	A.-s. Cu.	e. e.	1	Cu.	ne.
6	30.05	30.09	76.0	74.0	79	71	67.2	63	69.0	78	e.	4	ne.	14	0.00	T.	4	Cu.	e.	10	Cu.	ne.
7	30.12	30.16	75.5	74.0	78	72	67.3	65	67.0	69	ne.	24	e.	10	0.01	0.00	2	Cu.	e.	5	Cu.	ne.
8	30.16	30.14	75.0	73.0	78	69	66.0	62	68.0	78	ne.	14	ne.	20	0.00	T.	6	Cu.	e.	5 2	A.-s. Cu.	0(?) ne.
9	30.20	30.20	75.0	74.0	79	69	70.0	78	68.0	74	ne.	7	e.	15	0.03	0.05	9	Cu.	e.	6	Cu.	ne.
10	30.25	30.25	73.2	73.0	78	72	65.1	65	63.0	57	e.	15	ne.	4	0.01	0.00	9	Cu.	e.	4	Cu.	ne.
11	30.28	30.24	72.2	72.0	78	68	65.0	68	61.0	53	ne.	22	e.	9	T.	0.00	7	S.-cu.	e.	0	0	0
12	30.21	30.16	73.0	72.0	77	70	63.0	57	64.0	65	ne.	12	e.	15	0.00	0.00	7	Cu.	e.	Few	A.-s.	n.
13	30.16	30.11	74.0	71.5	76	71	62.5	52	65.5	72	e.	19	e.	9	0.00	0.00	3	Cu.	e.	8	S.	ne.
14	30.15	30.12	72.2	73.5	78	68	65.0	68	66.0	67	ne.	14	e.	10	T.	0.00	5 3	A.-cu. Cu.-s.	e. e.	6	S.	e.
15	30.12	30.11	74.7	70.0	79	68	67.0	67	68.0	90	n.	5	ne.	2	0.00	0.04	2 1	A.-cu. Cu.	e. e.	10	N.	ne.
16	30.17	30.14	74.7	73.0	78	69	66.0	64	65.0	65	e.	8	ne.	9	0.01	0.00	3 1	A.-cu. Cu.	e. e.	Few	A.-s.	se.
17	30.18	30.16	74.0	72.5	77	68	65.0	61	64.0	63	e.	17	e.	10	T.	T.	5	S.-cu.	e.	4	S.	e.
18	30.16	30.12	72.5	70.0	77	63	62.2	56	62.0	64	e.	15	ne.	16	0.00	0.19	4	Cu.	e.	2 1	Cu. Cu.-n.	e. ne.
19	30.12	30.08	72.0	70.0	76	64	64.0	65	66.0	81	ne.	12	e.	18	0.07	0.09	6	Cu.	e.	10	N.	ne.
20	30.15	30.13	66.4	71.0	74	64	65.1	94	63.0	64	e.	14	e.	9	0.96	0.21	3 5	Ci.-s. N.	0 e.	Few	S.	ne.
21	30.16	30.13	72.3	72.0	76	68	62.1	56	65.0	69	e.	5	ne.	9	0.10	0.00	4 4	Ci. Cu.	sw. e.	2	S.	e.
22	30.15	30.09	72.0	72.0	76	67	63.0	61	64.0	65	e.	13	e.	15	T.	T.	6 3	Ci.-s. S.-cu.	sw. e.	8	S.	e.
23	30.12	30.10	72.2	71.0	77	68	63.3	61	65.0	72	ne.	9	ne.	7	0.00	0.03	2 2	Ci.-s. Cu.	sw. e.	5	S.	ne.
24	30.11	30.07	71.2	64.5	75	63	63.0	63	64.0	97	ne.	11	ne.	17	0.05	0.19	4	Cu.	ne.	10	N.	ne.
25	30.11	30.08	66.5	65.0	70	61	57.7	58	58.0	66	ne.	23	ne.	15	0.60	T.	1	Cu.	ne.	2 4	S. N.	ne. ne.
26	30.08	30.00	65.0	65.0	70	61	59.5	75	59.0	70	ne.	10	ne.	12	T.	0.01	4	Cu.	e.	8	S.	ne.
27	30.09	30.06	64.2	67.5	74	61	62.1	89	63.0	78	n.	3	n.	3	0.02	0.00	7	S.-cu.	ne.	8	Cu.	ne.
28	30.10	30.07	71.0	70.0	76	66	63.0	64	63.0	68	ne.	8	e.	8	T.	0.00	4	A.-cu.	e.	7 1	A.-s. Cu.	0 ne.
29	30.05	30.00	70.6	69.0	76	67	64.0	70	64.0	76	ne.	2	ne.	10	0.00	0.00	9 Few	A.-cu. S.-cu.	w. e.	3 4	Cu. Cu.	ne. ne.
30	30.00	29.96	70.0	68.5	74	66	65.0	77	61.0	65	ne.	12	ne.	12	0.00	0.00	Few 1	A.-cu. S.-cu.	e. e.	8	A.-cu.	sw.
31	29.99	30.00	69.0	69.0	74	62	61.0	63	61.0	63	ne.	6	ne.	10	0.00	0.00	10	A.-s.	sw.	8 1 1	Ci.-s. (?) A.-s. (?) Cu.	0 0 ne.
Mean	30.109	30.086	72.1	70.9	76.5	67.3	64.4	66.2	64.5	70.8	ne.	11.0	ne.	10.3	1.87	0.81	5.5	Cu.	e.	5.6	Cu.	ne.

Observations are made at 8 a. m. and 8 p. m., local standard time, which is that of 157° 30′ west, and is 5h and 30m slower than 75th meridian time. *Pressure values are reduced to sea level and standard gravity.

Chart I. Hydrographs for Seven Principal Rivers of the United States, December, 1908.

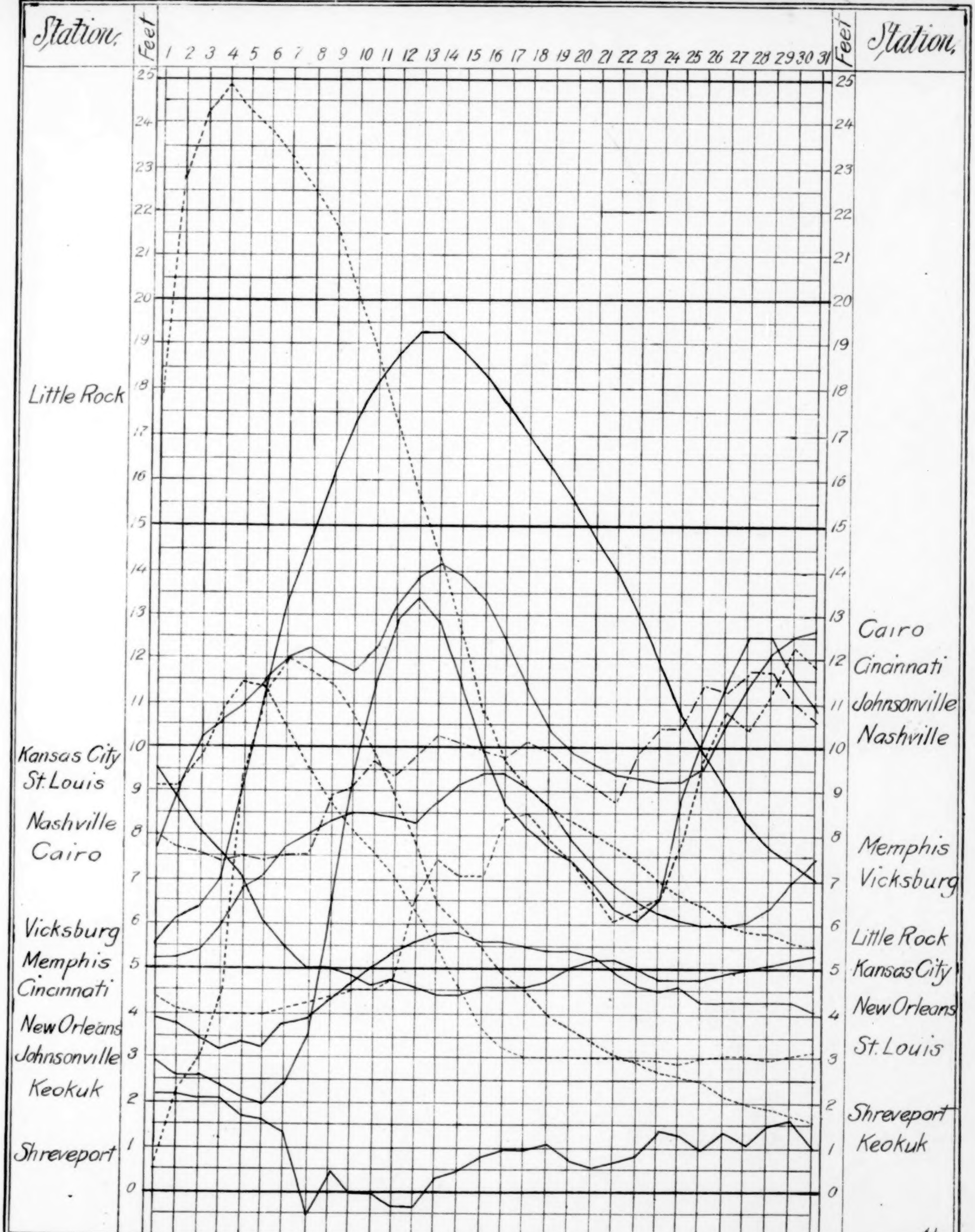


Chart II. Tracks of Centers of High Areas, December, 1908.

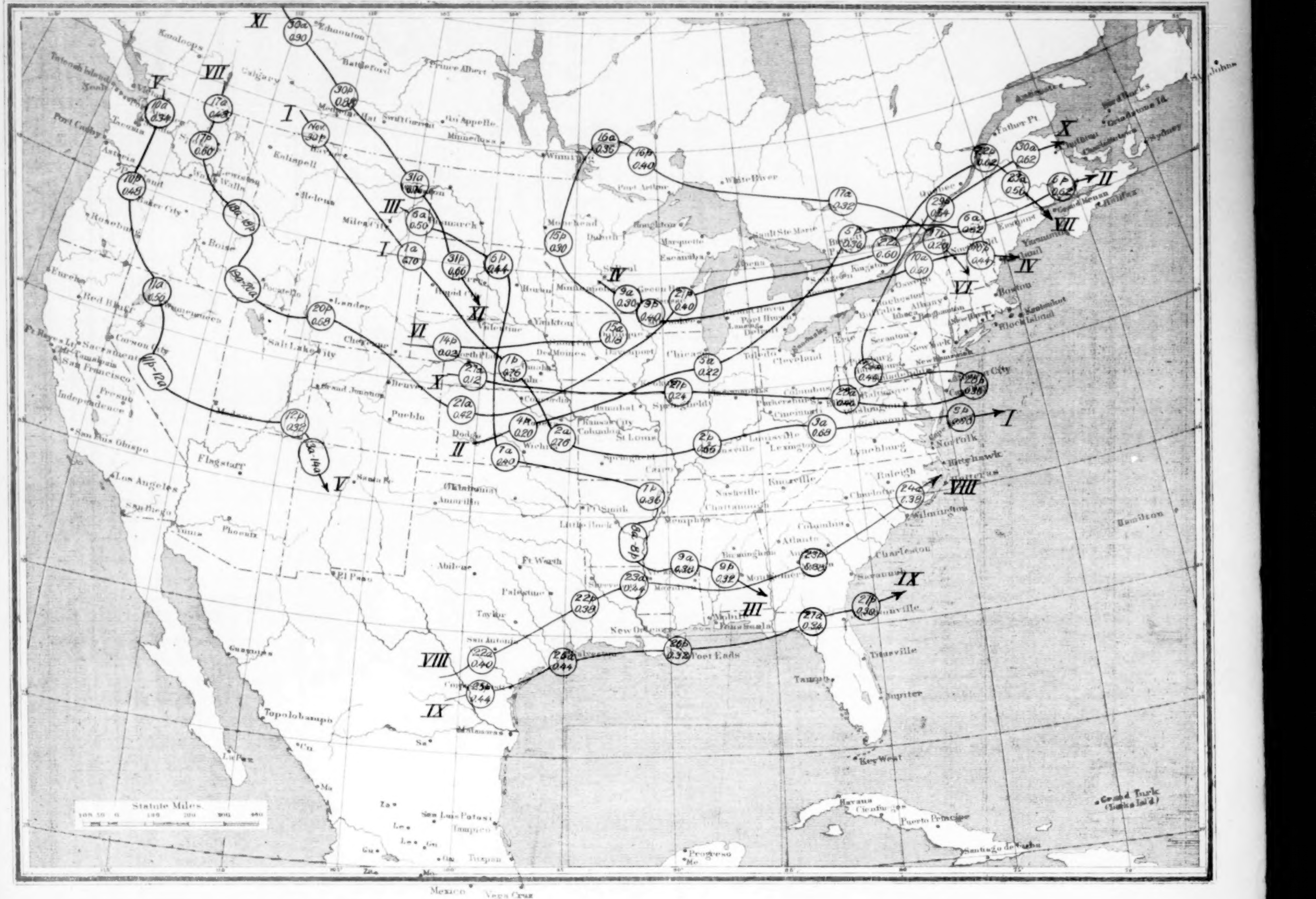


Chart III. Tracks of Centers of Low Areas, December, 1908.

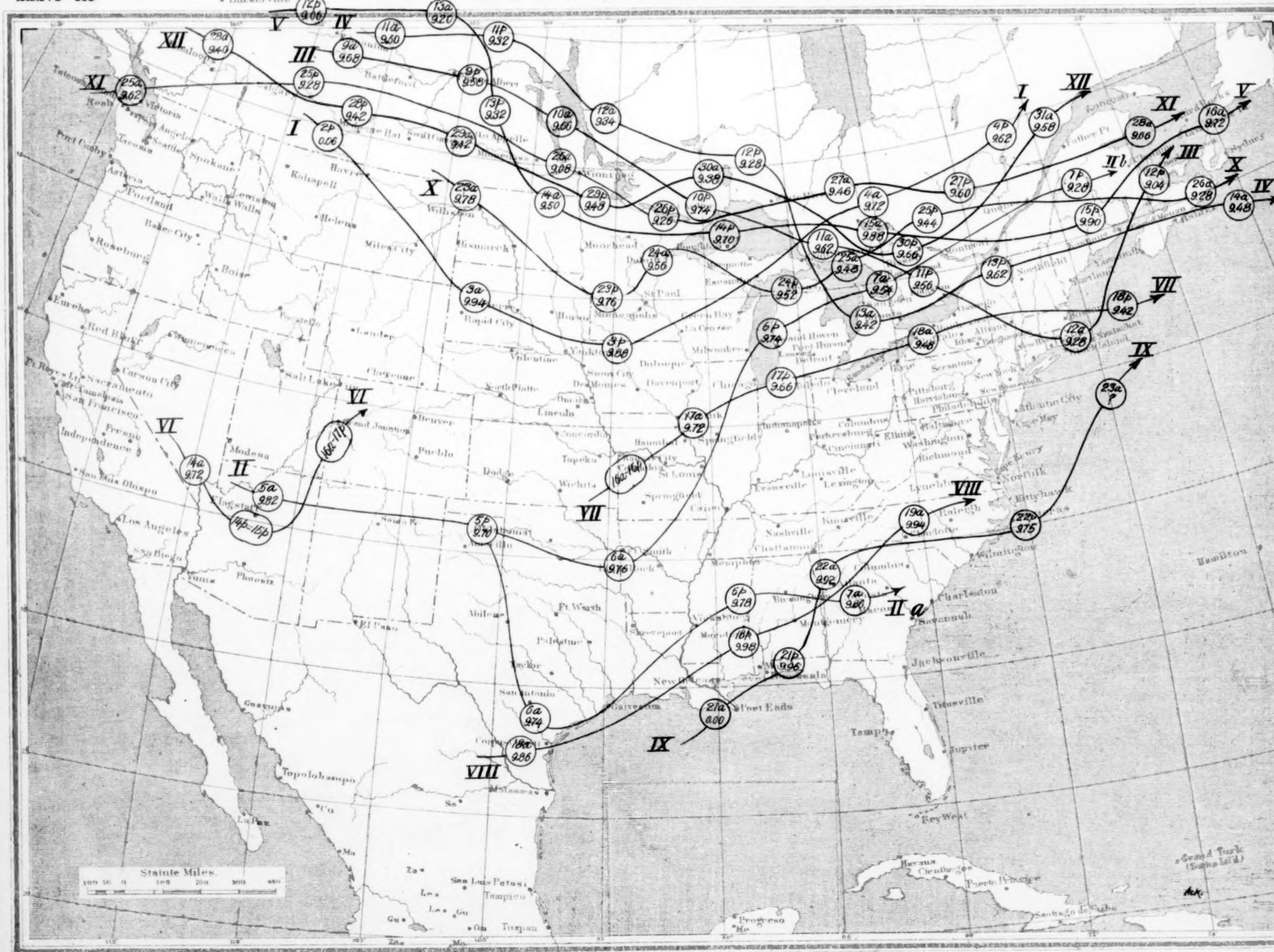


Chart IV Total Precipitation December, 1908.

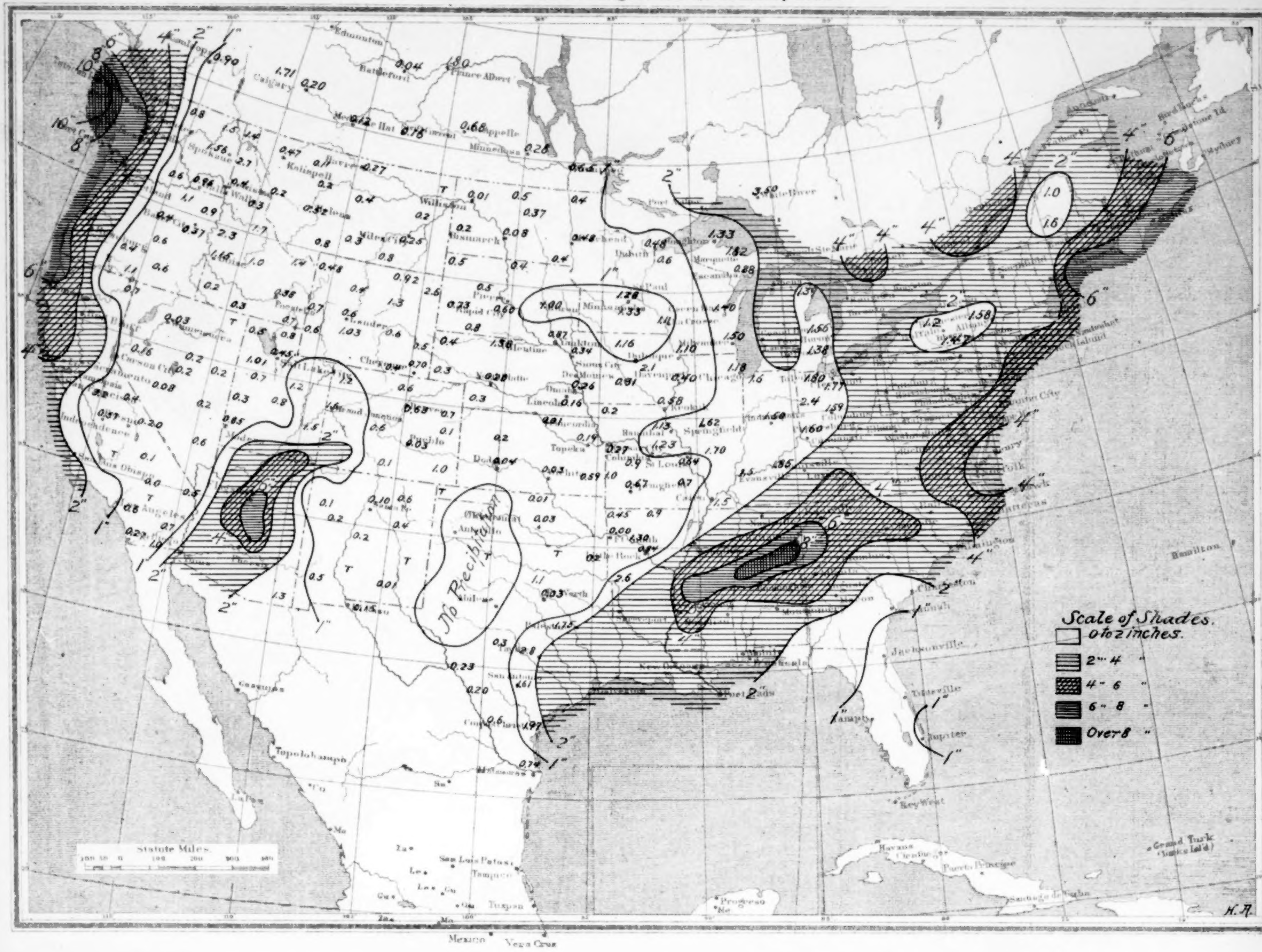


Chart V. Percentage of Clear Sky between Sunrise and Sunset, December, 1908.

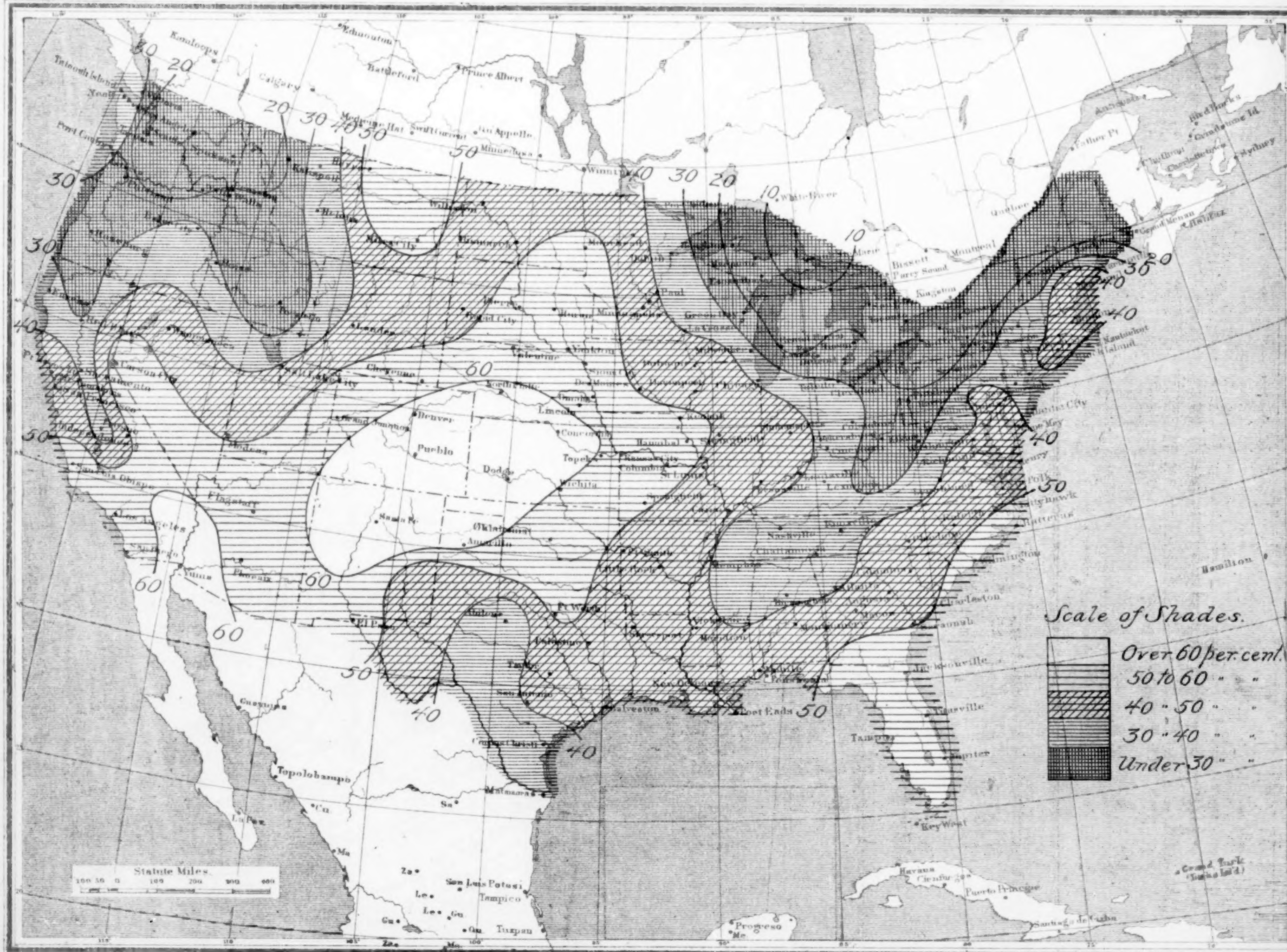


Chart VI. Isobars and Isotherms at Sea Level; Prevailing Winds, December, 1908.

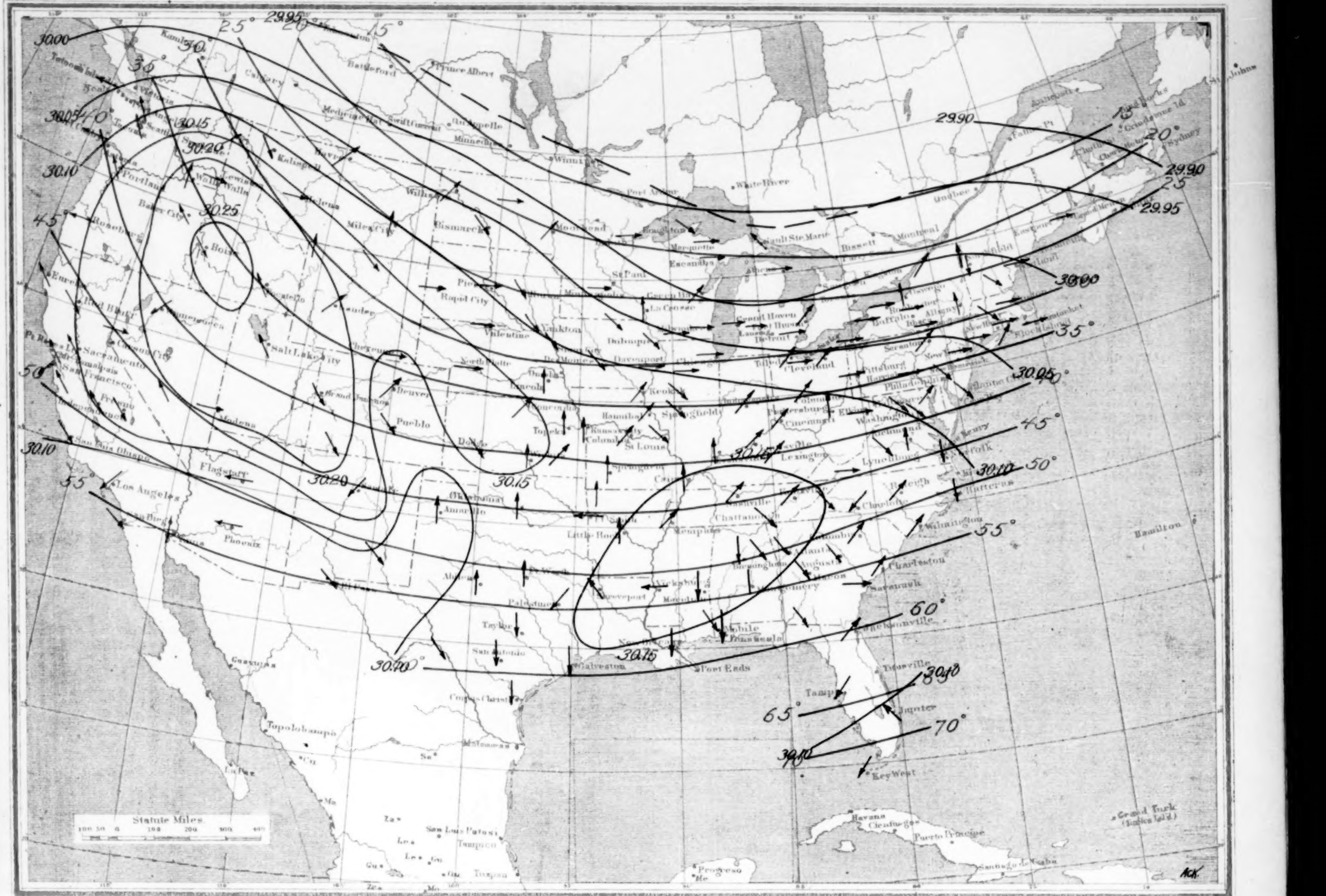
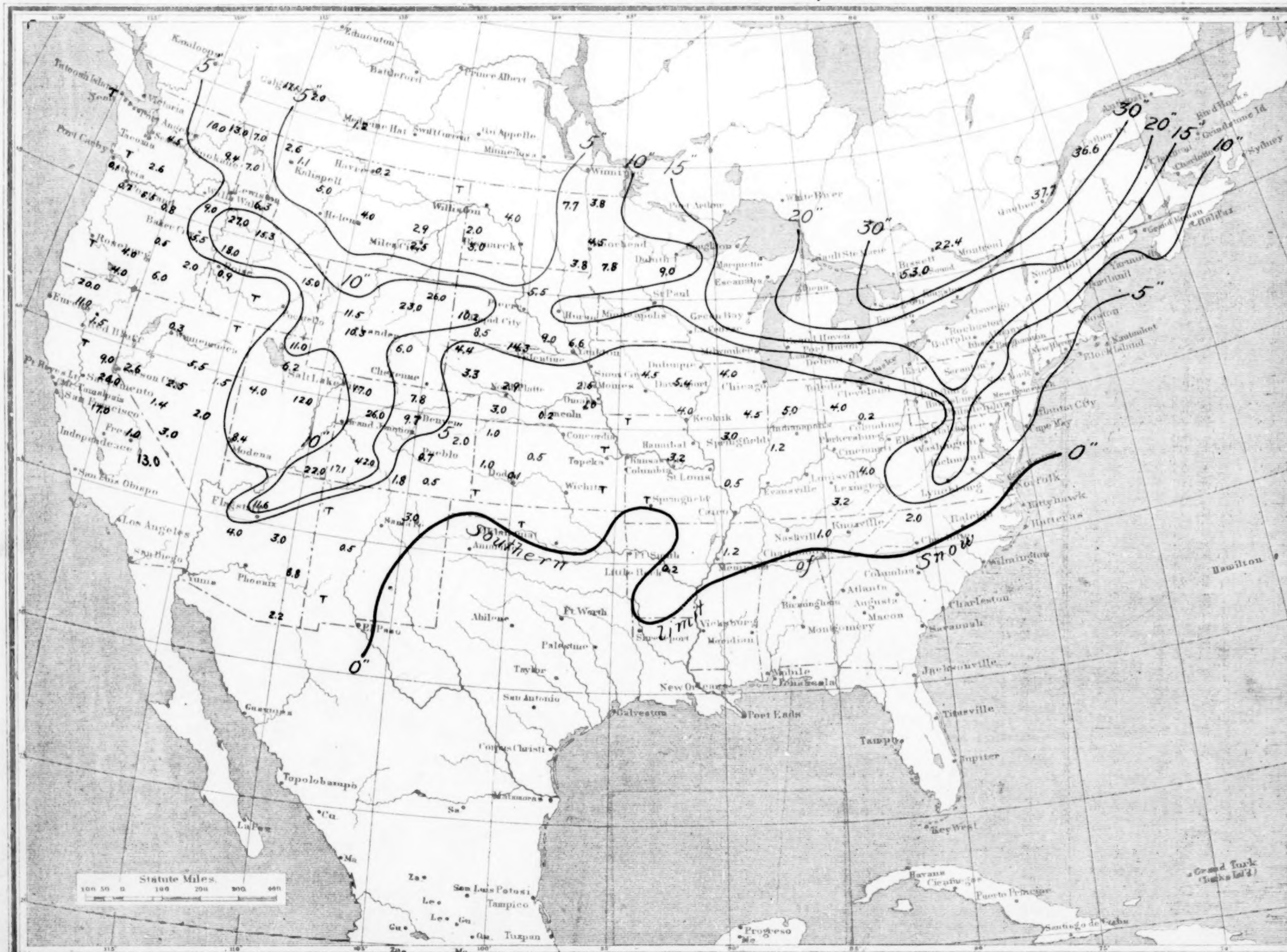


Chart VII. Total Snowfall for December, 1908.



• Barkerville

Chart VIII. Depth of Snow on Ground, December 31, 1908.

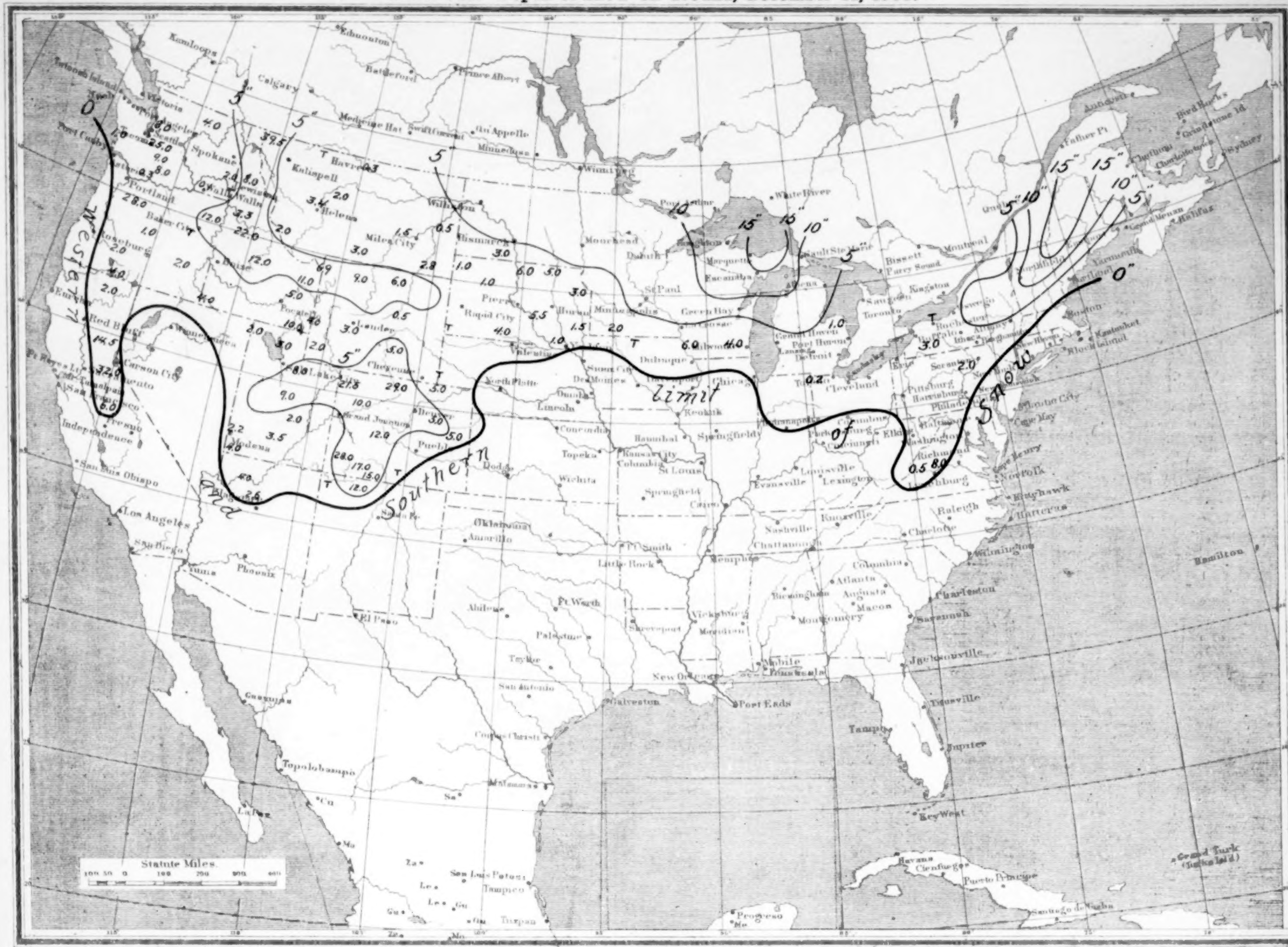


Chart IX. Marine Weather Maps from Wireless Reports, by P. Polis, August, 1908.

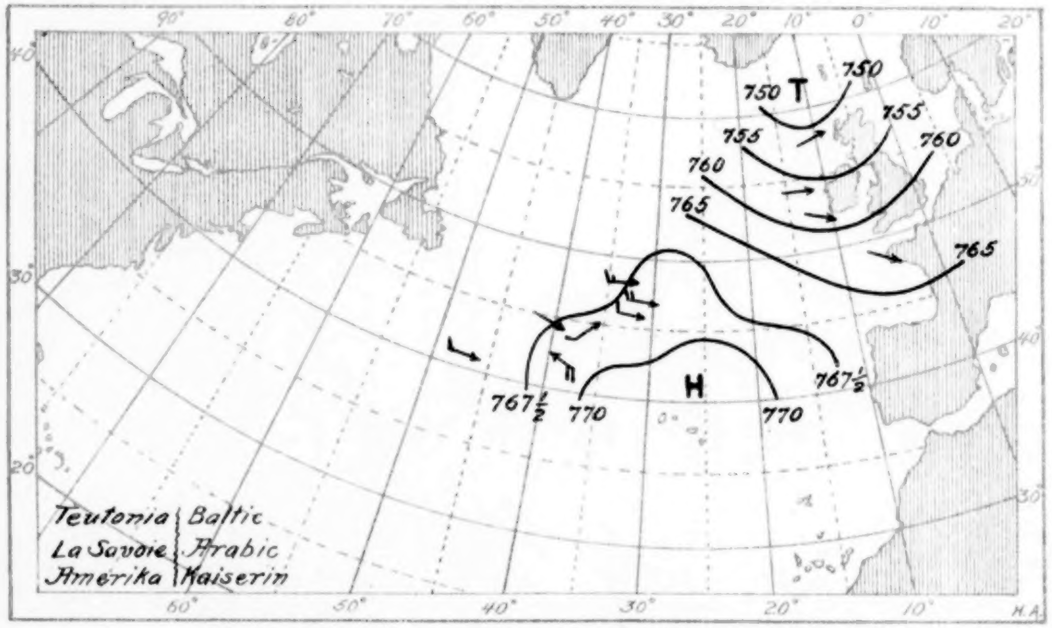


Fig. 1.—Map of August 10, 1908, 12 noon. G. M. T.

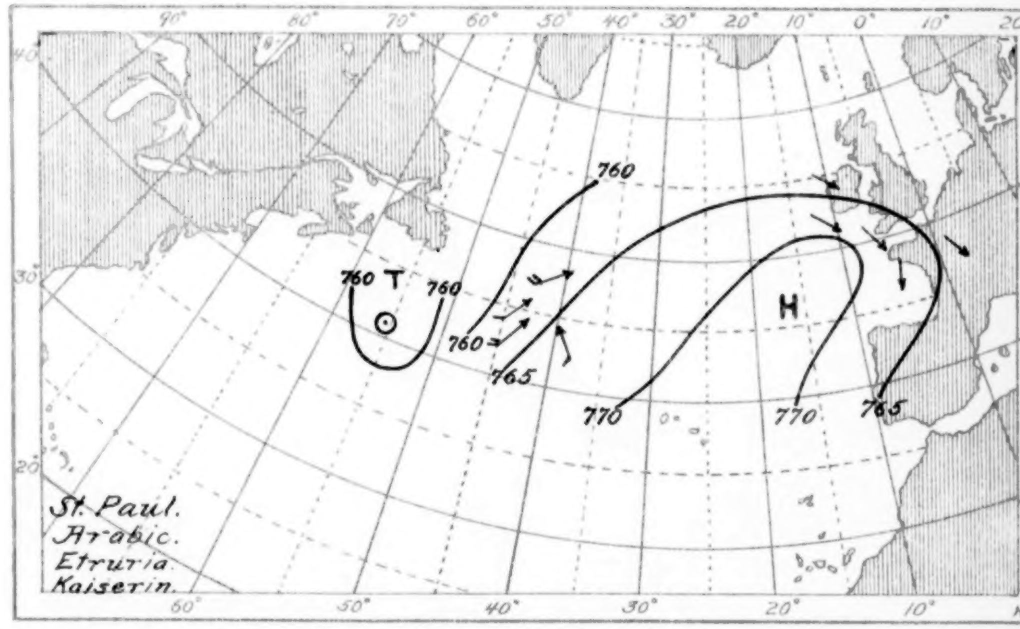


Fig. 2.—Map of August 11, 1908, 12 noon. G. M. T.

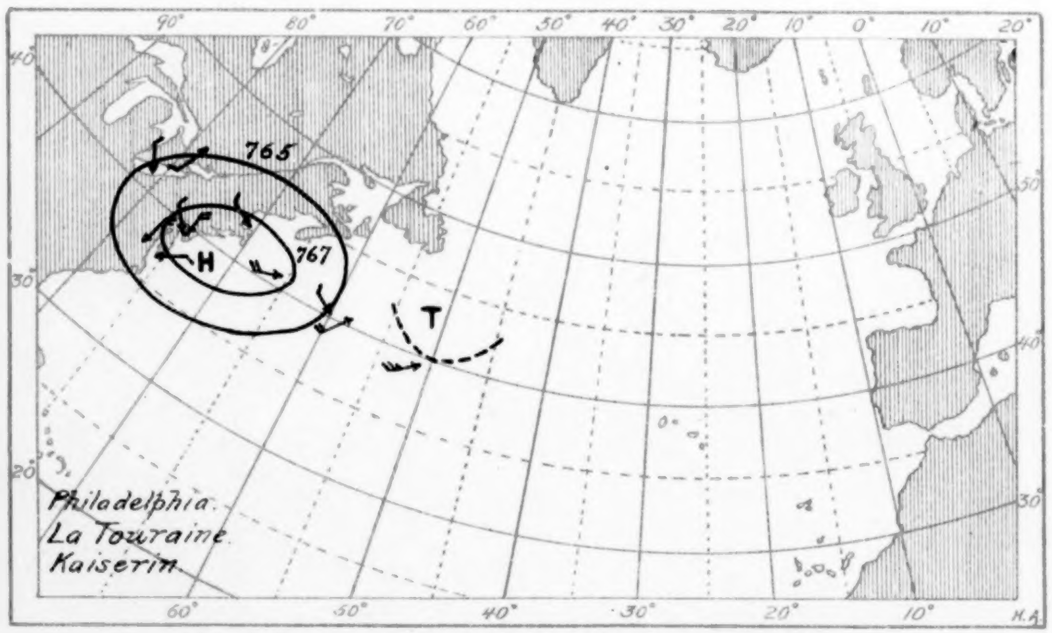


Fig. 3.—Map of August 21, 1908, 8 a. m. G. M. T.

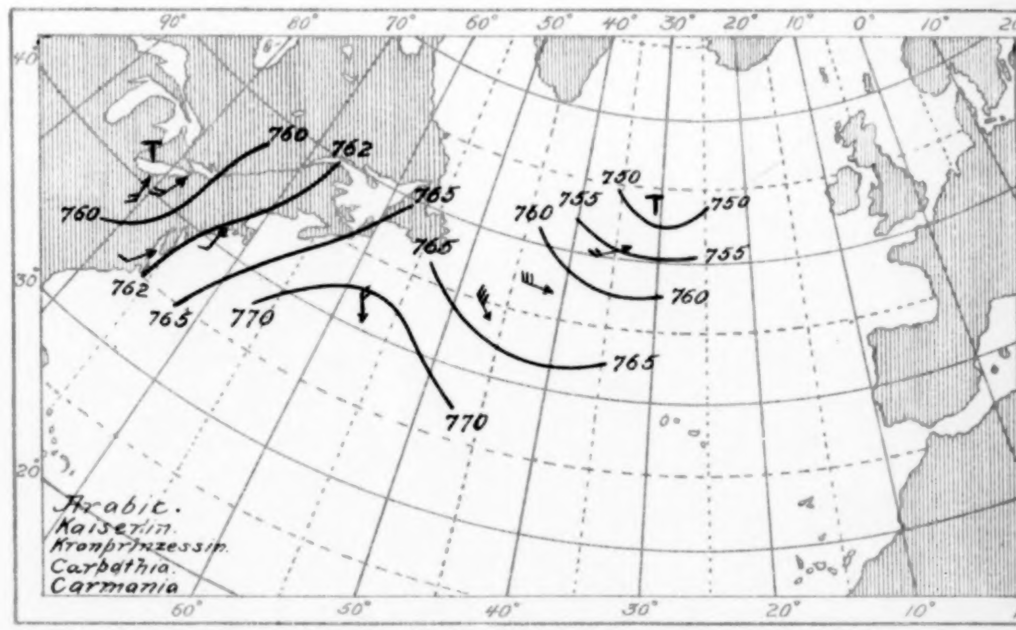


Fig. 4.—Map of August 22, 1908, 12 noon. G. M. T.